THURSDAY, DECEMBER 13, 1900.

ORGANOGRAPHY AND ITS RELATIONS TO BIOLOGICAL PROBLEMS.

Organographie der Pflanzen, insbesondere der Archegoniaten und Samenpflanzen. Von Dr. K. Goebel. Zweiter Theil. 2 Heft: Pteridophyta und Samenpflanzen. Mit 173 abbild. im text. Pp. xvi + 385 to 648. (Jena: Gustav Fischer, 1900.)

THE volume before us forms a further instalment of the large treatise on the organography of plants upon which Prof. Goebel is engaged. The part just published deals with the vegetative organs of the flowering plants, and, in a lesser degree, with the sporophyte and gametophyte of the vascular cryptogams.

It is needless to remark that the book teems with information, and, as might be anticipated, the author has drawn largely, for purposes of illustration, on the rich stores of material collected by him during his travels in various parts of the world. It is possible, however, that a layman on reading the book would arrive at the conclusion that in this particular field (of organography) other botanists had displayed far less activity than might have been expected from them, and would thus give them less credit than a closer acquaintance with either literature or the class-room would show they deserved.

The plan of the book is partly morphological, but woven into the morphological warp there is also the biological woof, and the author has emphasised, in a way which few could have done so well and, perhaps, no one more fully, the interdependence of these two groups of factors which so largely determine the actual form of existing plants. Goebel has long been known as an exponent of the concrete, and throughout the treatise one constantly finds traces of his antagonism towards that idealism into which, if the function of an organ be neglected, the morphologist is even still apt to stray.

Whilst tracing the various modifications which a given structure—*e.g.* a root—may exhibit in different plants, or in different parts of the same individual, the author constantly insists that these are, in fact, due to a deviation from the ordinary course of growth which commonly culminates in the formation of a normal root. Similarly, though it is more difficult to prove the point owing to their greater variety (depending on their more varied environment), the author argues that the modified leaf structures, scales, thorns, and so on, are brought about by causes acting on the developing primordium of what would, if unchecked, become a foliage-leaf. This latter is for Goebel the actual typical leaf, and from it, by an exaggeration or attenuation of parts which are already recognisable during its earlier stages, the modification occurring in any given example proceeds. He strenuously opposes the view advocated by some writers that the leaf-primordium is an indifferent structure, and regards it as normally destined to give rise to an ordinary leaf. He has himself, more, perhaps, than any one else, shown how easy it is in some cases to interfere with those causes or sequences of events leading to the modification of such an organ, and thereby to effect a reversion in favour of the more primitive organ to take place. Probably most people would be inclined to admit that, on the whole, the main lines of evidence go to prove that the obvious assumption made by Goebel in this connection with regard to the original character of the organ is a valid one.

It must, however, be confessed, and any one at all conversant with contemporary literature will recognise the fact, that there exists some danger of attaching a one-sided importance to the readiness with which organisms adapt themselves to the exigencies of a changed environment. For the response in form and structure is often so direct and obviously purposeful that more stress is apt to be laid on the stimulus itself than on the nature of the body to be stimulated, with its complex and varied mechanism, and there are some who have gone so far as to read into this purposeful variation an immediate explanation of the formation of new or incipient varieties; as though the real fact which mainly stands in need of analysis were not the very one constituted by this self-same *purposeful* character of the response. And indeed it would appear, upon reflection, that this form of response is itself the result of the operation of natural selection which has acted by eliminating the chance of leaving descendants from all those competitors in whom the reaction to a given set of conditions happened to fall short of a certain standard of perfection. It need not necessarily follow that all must have varied in an identical manner, but those that failed to comply, by *some* suitable change or another, with the requirements imposed by the new conditions, must inevitably be ousted by their more gifted rivals, and if these assumed changing conditions periodically recur, then the process of elimination will result in those only being left in which the power to respond accurately (*i.e.* purposefully), and it may be rapidly, to a particular change has been best developed and cultivated.

It is obvious that a similar result, *mutatis mutandis*, would follow if a complex variety of stimuli be substituted for the simple case touched on above, and thus a protoplasmic mechanism is gradually selected and perfected which, when stimulated by any means to which there can be a response at all, will reply by the corresponding reaction normal for that species or race. But though normal in kind for the race, its degree will vary in different individuals, as any one can readily prove by direct observation. Hence it at once becomes subject to the operation of natural selection. Naturally, so long as a particular stimulus is absent the corresponding response, however well tuned and ready, will remain in abeyance as a latent potentiality.

A study of plants reveals numerous examples of this. Amphibious plants frequently are able to assume alternative characters, respectively fitted for either a terrestrial or an aquatic habit, and it depends entirely on the nature of the stimulus arising from the environment as to which of the two types of structure shall appear. Such plants, during their species-life, have been repeatedly exposed to vicissitudes of a somewhat extreme character, and the latent ability to change so as to adapt themselves more fully to altered circumstances must have played no unimportant part in securing the survival of their race. Many other examples could be quoted to show how important for stationary beings like plants is the possession

of a very plastic organisation, that is, one which will respond readily and *accurately* to the demands of the external conditions of life. For plasticity is clearly only of use (and therefore will come to a like extent within the purview of natural selection) in so far as it will provide the organism with the power of striking the right note in response to a particular call.

On the other hand, there are plants which may have become, for example, specially selected on account of their ability to flourish in dry, hot, desert lands. Such plants might be expected to retain slender powers of responding in a manner favourable to the continuance of life under opposite hygrometric conditions; and every one is aware how extremely intolerant of moisture are the cacti and some other xerophytic plants. Nor is this surprising, seeing how trivial a part the development of a purposeful adaptation to satisfy the needs of a damp environment can have played in their ancestral experience, and indeed the chance of any individual amongst them possessing the power of responding quickly and appropriately to such conditions, to which they are never exposed, is an exceedingly remote one. It is otherwise with species that inhabit regions which, though usually dry, are occasionally or periodically exposed to different conditions. That the plants living in such places, though they may be mainly of a xerophytic habit, nevertheless retain the faculty of withstanding wet is precisely what one would have been led to anticipate, and there are plenty of examples in which the alternation of dry and wet seasons is accompanied by a change in habit analogous to that exhibited by our own trees in summer and winter respectively. An immense weight of evidence has been accumulated by those who have helped to elucidate these matters which goes to prove that the power to vary in any given direction is possessed in an unequal degree, not merely by individuals of the same species, but even in those growing side by side, and thus apparently exposed to very similar conditions.

This fact at once emphasises the importance of the preexisting *internal* factor of variation, and it also explains the existence of a criterion which can determine what individuals shall survive in the struggle imposed by new or changing conditions. The particular variation elicited in any given instance is merely the outward and visible sign of the operation of an inward organisation or mechanism. It is the latter which, forming an integral part of the parental constitution, will be transmitted to the offspring. And if those individuals which possess the special organisation in the highest degree are thereby enabled to leave the most vigorous or favourably situated descendants, that character, which is its outward token, will become correspondingly strengthened till it comes to form a mark of the race. It is the function of the environment to prove the individual capacity in that contest where the race is emphatically to the swift and the battle to the strong.

Hence, it would seem that not variability only, but that special (purposeful) form of it which enables so many organisms to make suitable responses to divergent conditions of life ought to be, as the outcome of the effect of natural selection, a feature of very general occurrence; and it ought to be most strongly developed in organisms living under changing or changeable conditions, and such is found to be the case. One may almost assert that the purposefulness of a particular reaction is a measure of the perfectedness of the stimulable mechanism, itself a heritage transmitted through a long ancestral line of individual bodies.

This view of the matter is obviously in no wise altered, if we admit the occurrence of sudden or discontinuous variations. For these also are themselves congenital in their origin, and all that the environment can do is to encourage the manifestation of a variation (if a favourable one) in as high a degree as the organism can develop it. Nor is the position affected if we allow that a structural reaction may proximately result from a change in the metabolic processes of the organism, such as Sachs, and Goebel following him, have supposed. In fact, there are some familiar instances which hardly admit of any other explanation, as, for example, when different kinds of galls are produced on the same individual oak-tree by different insects. Facts such as these merely shift inquiry to another stage, and it is certainly not less difficult, in these and similar cases, to account for the particular antecedent reactions going on within the plant in such a way as to produce a substance capable of acting as an appropriate stimulus, which shall provoke a reaction in the plant useful to the grub which originates it.

Into the questions as to the origin of the causes of variations themselves, this is naturally not the place to enter; nor does a consideration of the problems concerned with the nature of those variations which may arise correlatively, or which are more or less obscurely conditioned by remote causes residing within the organism itself, and which may appear suddenly, without any immediate reference to their adaptedness to contemporary needs, fall within the scope of this article. It is enough to emphasise the point that the occurrence of purposeful reactions to specific stimuli is really in complete harmony with the operation of natural selection acting through the medium of a congenitally varying organisation.

Turning again to the subject-matter of Prof. Goebel's book, one finds that not only is it replete with interesting results of biological inquiries, but that there are scattered through its pages excellent little essays on morphological subjects. As an example of the former may be cited the explanation of the mechanism which brings about the dehiscence of the antheridia, a topic which has already formed the basis for investigations published from the author's laboratory. The instance of Azolla, too, in which the lower leaf lobe is shown to have an absorbent function, is attractive when the analogous case of Salvinia is recalled.

The critical treatment of the structure of the grass embryo is an admirable piece of comparative morphology. Prof. Goebel regards the cotyledon as consisting of the scutellum, epiblast and the sheath or coleoptile. His views are supported by evidence drawn from a consideration of a large number of other monocotyledons, especially the Cyperaceæ, and whether one agrees with his conclusions or not, one cannot but praise the way in which the evidence for them is collected and marshalled. The views put forward as to the homologies existing between the cells formed within the germinating microspores of some of the vascular cryptogams will probably provoke criticism, as will also the suggested phylogeny

of the gymnosperms, which the author appears to regard as derived partly from the Ferns and partly from the Lycopods.

As regards the book, viewed as a whole, it is impossible not to feel that, in spite of—perhaps partly in consequence of—its extraordinary wealth of illustration, it does not help us much farther towards a more general conception of the value and wider relations of organography as a whole. But, nevertheless, the experimental line of inquiry in this field, which Goebel himself has so ably pursued, is one which will certainly prove a fruitful one, judging from the results which have even yet accrued. And for the clear indication of this, as well as for the bringing together such a vast store of facts, the author has thoroughly earned the gratitude of his fellow-workers. It is just because there is so much of good in the book that it is difficult to avoid giving expression to that kind of gratitude which still hopes for something yet more satisfying. J. B. FARMER.

THE HISTORY OF THE DEVIL.

The History of the Devil and the Idea of Evil. By Dr. Paul Carus. 8vo. pp. xvi+488. (London: Kegan Paul and Co., Ltd. Chicago: The Open Court Publishing Company, 1900.)

THE volume before us is one of considerable interest, but we must say at once that we think the history of the Devil and of the idea of evil should have been treated in a manner different from that which has been adopted by Dr. Paul Carus. The discussion of the idea of evil is a matter for the philosophical thinker, it seems to us, and the subject cannot be threshed out in detail in a single volume by any writer, however able he may be; the history of the manner in which the Devil, *i.e.*, the personification of evil, has been depicted by various peoples at various times in various places over the earth, is quite a different subject, and is, likewise, one which cannot be treated adequately in a single small volume. Dr. Carus, however, has tried to deal with *both* sides of this complex subject in one volume, and, it must be confessed, he will, in consequence, not satisfy either the philosopher or the iconographer. His book is well printed and well illustrated—though we certainly do not admire the shadowy "ghost" pictures printed in a sickly green colour on several of the pages—and to many readers it will be of interest, and probably of use also, for it may stimulate them to investigate the subject for themselves. In eighteen chapters, which vary considerably in length, the history of the Devil and the idea of evil are discussed in connection with the evidence derived from pictures, reliefs, &c., from Egypt, Akkad, Babylonia, Persia, Judea, India, China, Europe, and other countries, but Dr. Carus has not collected all the facts which he ought to have gathered together, and his deductions from those he gives are hardly correct. We do not think that "the belief in good spirits tended towards the formation of the doctrine of Monotheism," or that "the belief in evil spirits led naturally to the acceptance of a single supreme evil deity." Prehistoric man peopled all earth, air, sea and sky with spirits, some of whom were supposed to be hostile to him, and others benevolent; and he regarded a spirit as good or evil according to whether it did him good or evil. When a series of good harvests came to him, or he was singularly fortunate in love, or the chase, or war, he made up his mind that the good spirits had succeeded in destroying the power of those who were evil. In process of time, to certain evil and to certain good spirits extraordinary powers were ascribed, and eventually the idea of the existence of a prince of evil, as well as of a prince of good, was formulated; terror and ignorance were the chief constituents in the worship of primitive man, and physical and moral attributes, as well as cause and effect, were often confounded by him.

Dr. Carus regards the old Egyptian god Set as the equivalent of the Devil of the later peoples of the West, but this is only partly true. He was a nature power and was the twin brother of Osiris according to one legend, and the twin brother of Horus the Elder according to another. He was the male counterpart of Nephthys who, as is well known, was not hostile to Osiris, and he must not be confounded with Âpep, the mighty enemy of Rā, the Sun-god; Set and Horus together held up the ladder whereby the deceased entered heaven, and both gods gave him a helping hand in mounting it. Dr. Carus is mistaken when he says that Set "was converted into Satan with the rise of the worship of Osiris." We know nothing about the rise of the worship of Osiris, but we learn from the Pyramid Texts that in the fifth dynasty, when the worship of Osiris was universal in Egypt, Set was regarded as a benevolent god and a friend of the deceased. In speaking of Akkad and the early Semites, Dr. Carus is either credulous or rash, for, after saying that the Babylonians "possessed several legends which have been received into the Old Testament," he mentions a legend of the Tower of Babel and of the "destruction of corrupt cities by a rain of fire," reminding us of Sodom and Gomorrah. The text on which he relies for the legend of the Tower of Babel is, of course, K. 3657 in the British Museum, but a recent examination of the tablet proves that it has nothing to do with the Tower of Babel; as for the legend of the cities which were destroyed by "a rain of fire," we cannot imagine what the authority can be. We may mention, in passing, that many of Dr. Carus's authorities are altogether obsolete, and it is possible that one of them has led him astray on this point. His interpretations of Babylonian scenes, too, are not always correct. Thus on p. 40 the "Chaldean Trinity" is not blessing the tree of life, but is merely appearing above the conventionalised representation of the palm tree to the priest who is worshipping before the image of the god; similarly, the statement (p. 46) that the bronze tablet of the de Clercq Collection is a representation of "the world in the clutches of an evil demon' is erroneous. Any account of the demonology of the Assyrians and Babylonians which does not take into account the *Shurpu* and *Maklu* series of magical tablets which have been recently published by Tallquist and Zimmern must of necessity be most incomplete, and we are not a little surprised that Dr. Carus should have undertaken the task without doing so. The demonology of the Israelites is dismissed in nine pages, and this section of the book is most disappointing; in recent years many workers have investigated the Hebrew side of the subject of devil-lore, and an extremely interesting chapter might have been compiled from their writings. The famous

old work of Eisenmenger alone would have afforded him abundant material for a very long essay wherein every statement might have been founded upon fact.

In the chapters of Dr. Carus's work which are devoted to the "Dawn of a New Era" and "Early Christianity," the same complaint must be made, *i.e.*, he has not used existing materials. Who in these days would attempt to write about Gnosticism without giving a good account of the Pistis Sophia, or of the Book of Ieu, works from which the most valuable information on the subject is to be derived? It seems almost as if Dr. Carus had written his book to suit the pictures which he gives, without paying any attention to the system or arrangement of his work. In a treatise of such pretensions we should expect the account of the demonologies of the various Semitic nations to be kept together, and, as the devils of the Gnostics and early Christians were descendants of the denizens of the Egyptian underworld, they ought to have been described in a connected and systematic manner. It is doubtful how far the histories of the Inquisition and of the persecution of witches have any right to be in a book of this kind, but if they have, they should have been greatly shortened; in fact, Dr. Carus's work needs careful editing by a skilful but somewhat severe editor. As a picture book it is interesting enough, but as a scientific contribution to the history of an interesting and important subject it is, in our opinion, of little value.

SIR H. MAXWELL'S "MEMORIES OF THE MONTHS."

Memories of the Months. Second Series. By the Right Hon. Sir Herbert Maxwell, Bart. Pp. xv + 295. Illustrated. (London: E. Arnold, 1900.)

IT falls to the lot of but few among us to be all-round sportsmen, good naturalists, entertaining and versatile writers, and philosophers to boot; and yet all these varied and valuable accomplishments are the attributes of the author of the delightful and entertaining volume before us. A few years ago, as the author tells us in the preface, he published selections from his note-books of several seasons under the title quoted above, and these met with such a favourable reception that, at the request of numerous readers from both sides of the Atlantic, he has been induced to print a second series. And the public are decidedly the gainers by this resolve. For whether discussing the kind of salmon-fly best suited to any particular season or river, the utility or otherwise of birds or mammals commonly persecuted by the farmer and the gamekeeper, the kinds of shrubs and plants best suited to escape the depredations of rabbits, the ruthless slaughter of egrets for the sake of their so-called "osprey" plumes, or the accident by which the skeletons of the iguanodons of Bernissart were preserved for the delectation and wonderment of the present generation, he is equally at home, and equally free from any suspicion of dulness and pedantry.

Nothing, indeed, seems to come amiss to Sir Herbert in the matter of a text, and he has the rare faculty of making an extract from some abstruse scientific paper as full of interest as are his observations on the mammals, birds and fishes with which he has come in contact in the ordinary course of a country life or in his field sports.

Among the subjects to which the author has paid special attention is the so-called vole-plague, which wrought devastation some years ago over wide districts in Scotland. Of the committee appointed to investigate the causes of this invasion, and, if possible, to suggest remedies, he was appointed chairman. And he gives a graphic account of the scene which met the eye during the visits of the committee to the afflicted area, mentioning the extraordinary number of short-eared owls which flocked to the feast, and of their equally remarkable fecundity as its result. Lappwings, too, are birds which come in for a special share of his attention; and although he apparently considers that much harm has not been done thus far, yet he urges that shooting a bird at one season and taking its eggs at another, or even conducting both operations simultaneously, is a sure road to its eventual extermination. While deprecating any interference with the collecting of these plovers' eggs, he suggests that the slaughter of the birds themselves should be prohibited.

An enthusiastic angler, the author holds out hopes of the possible rehabilitation of the salmon in the upper reaches of the Thames, stating that even at the present day the condition of the water at the mouth of that river is such as to offer no barrier to the upward passage of the fish. But he points out that as there are now no salmon-rivers discharging in the neighbourhood of the Thames estuary, it is essential that young salmon must be turned down in that river itself, when there would be hope that some of them would return after their first excursion to the sea. From Thames salmon the transition is easy to the question as to whether *Salmo salar* really abstains from food while in fresh water. In regard to this latter point, Sir H. Maxwell states that the experience of many anglers is practically in accord with the results of the investigation carried on by the Scottish Fishery Board, as detailed in a "blue-book" published in 1898, namely, that salmon do, as a rule, fast during the period in question. Against this evidence is, however, advanced the undoubted fact "that salmon in fresh water do take and swallow worms, minnows, and similar objects." And the pertinent question is asked with what object they take them if not to eat. "The simplest solution is probably the true one—namely, that even a physiological fast is compatible with occasional and irregular impulses of appetite, which exactly corresponds with the well-known capriciousness of salmon in taking any lure."

But to follow the author further in his interesting discussions on fish and fishing would spin out this notice to an inordinate length. And it ought to be mentioned that the mole is one of the animals he considers should be protected rather than destroyed, as it appears to be of incalculable value in destroying the larvæ of "daddy-long-legs" and other equally noxious grubs. On the other hand, Sir Herbert has not a single good word to say for the rabbit, which he terms an "accursed" creature.

Hitherto we have referred to the author's zoological and sporting notes; but an equal degree of interest is taken by him in botany, and the mention of the extraordinary abundance of holly blossom in the home counties during the summer of 1899, coupled with his observations on

the remarkable "mimicry" of the plane by the sycamore, will serve to indicate the amount of attention bestowed by the author on botanical subjects. The incident related on page 87, narrating how a Scotch minister caused all the daffodils in his churchyard to be mown down because his wife regarded yellow as a vulgar colour, is a curious example of mid-century "æstheticism." To those fond of their gardens, the hints given as to the kinds of shrubs and herbaceous plants that flourish best in this country will be acceptable.

With the number of subjects on which the author touches it would not be surprising if he fell here and there into error. And yet there are but two passages which we have found occasion to criticise in this respect. In the first of these (page 89) we fail to realise how ice is likely to have had any share in the transport of the remains of the Bernissart iguanodons. The other is the statement (p. 46) that the nightjar, or goatsucker, is a relative of the swallow, whereas it is, of course, to the swifts that this bird is really allied. That the statement is not due to an accidental slip of the pen is proved by its repetition on page 233. These, however, are but trivial blemishes. And to whatever page he may turn, the reader can scarcely fail to be interested in what the author has to tell him. Whether, indeed, to while away an idle half hour at home, on a railway journey, or as a companion in the field, it would be difficult to find a more entertaining and instructive work of its kind. The epithet "delightful" suits it exactly. R. L.

OUR BOOK SHELF.

Cinématique et Mécanismes, Potentiel et Mécanique des Fluides. Cours Professé à la Sorbonne. Par H. Poincaré; redigé par A. Guillet. Pp. i + 385. (Paris: Carré et Naud, 1899.)

THIS book is edited from a course of lectures given at the Sorbonne. The first part deals with the kinematics of rigid bodies in two and in three dimensions, including the theories of roulettes, of acceleration centres and of relative motion; and concludes with a chapter on simple mechanisms. These are all well-worn topics, and afford little opportunity for novelty of treatment. In the few pages devoted to finite rotations we notice, however, an elegant method of investigating Rodrigues's formulæ which is, at all events, not current in this country. The exposition is marked throughout by the author's usual facility, and the illustrations are well chosen. A severe taste might perhaps take exception to the way in which analysis and geometry are continually mixed up in the proofs, but a course of lectures intended primarily for a special class of students is not to be judged by the same canons as a formal treatise.

The second part gives, in about 180 pages of large type, a rapid sketch of the theory of the potential, the attraction of ellipsoids, hydrostatics and hydrodynamics. A number of leading propositions are introduced, but the treatment is necessarily fragmentary, and in some instances it might be difficult to account for the precise selection which has been made. The brief chapter on hydrodynamics is disappointing. We notice, in particular, that Poisson's proof of Lagrange's velocity-potential theorem is reproduced without a word of warning as to its defects; and on p. 330 we have the following mysterious sentence: "On a discuté la question de savoir si un liquide visqueux est encore soumis au théorème de Lagrange; *les opinions sont partagés!*" Again, on p. 339, the remark: "Il est impossible de déterminer théoriquement le coefficient de contraction," might surely be qualified. It is a little strange to find the labours of Stokes and Kirchhoff on these points entirely ignored, even in an informal publication like the present. The absence throughout of all reference to authorities is, indeed, to be regretted; such references can, of course, be only sparingly made in actual lectures, but they might well be introduced in the process of editing.

It would be ungracious not to add that although, from the nature of the subject, the present treatise is not likely to excite such widespread interest as some of its predecessors, probably few readers will be found to lay it down without a fresh feeling of admiration for the energy and versatility of its author. H. L.

A Contents-Subject Index to General and Periodical Literature. By A. Cotgreave. Pp. xii + 744. (London: Elliot Stock, 1900.)

THIS is an attempt to bring together and classify in alphabetical order the noteworthy contents of periodicals and some other publications.

Several indexes to periodical literature are in existence, and are appreciated by people who have cultivated the habit of verifying references. Mr. Cotgreave has produced an index which will prove a handy and inexpensive guide, and an examination of it suggests that a similar work, prepared by a body of experts instead of one man, and issued periodically, would be of distinct value.

The index is not complete—nor does it pretend to be, but it is a praiseworthy attempt to classify a mass of heterogeneous articles, books and papers into subjects. Any one desirous to know a few contributions on any subject has only to refer to the index and he will find some to serve his purpose, though not always the best. We are only concerned with the scientific subjects, and have examined the entries from this point of view. The result is not very satisfactory, for some of the best contributions to science do not appear—at any rate where we should naturally expect to find them. Why should Barff's "Chemistry" and Reynolds' "Chemistry" be selected as containing accounts of the composition of air, while many other much better descriptions have been published? Why, again, should Johnston's "Chemistry of Common Life" be the only book given under the composition of air? Under physical geography there are six titles, three of which are unimportant; the only title under natural philosophy is Mitchell's "Orbs of Heaven"; an article on cellulose is classified under natural science; Balfour Stewart's Physics Primer is the only book cited under the title "laws of electricity"; Ashby's "Physiology" is the only reference given for a description of the metric system; the British Museum catalogue and introduction to the study of meteorites is not mentioned under meteorites; and many other similar cases could be given. We understand, of course, that the index is an eclectic one, and are willing to acknowledge that much work must have been expended in its preparation; but its limitations and imperfections must nevertheless be pointed out. If it is borne in mind that the book only contains a general survey of literature, it will be found of service.

Workshop Mathematics. By Frank Castle, M.I.M.E. Part i., pp. viii + 154. Part ii., pp. ix + 177. (London: Macmillan and Co., Ltd., 1900)

PROF. PERRY'S persistent advocacy of a system of mathematical instruction adapted to modern requirements is bearing fruit in the shape of text-books, which will probably do more to induce teachers to adopt rational methods than the most convincing statement in favour of them. Mr. Castle has already prepared a book on "Practical Mathematics" which covers substantially all the subjects in the syllabus drawn up by Prof. Perry for

the Board of Education, South Kensington. The two little books under notice have been written in the same spirit, and contain some sections from the previous volume, but the treatment is more elementary and many new exercises are given.

In Part i. the subjects dealt with belong to arithmetic, algebra and the mensuration of parallelograms, triangles and polygons. Prominence is given to contracted methods, use of decimals, and explanations of algebraical expressions. Scales, calipers, and other simple measuring instruments are described in the chapters dealing with mensuration, and their use is well exemplified. Part ii. is devoted to logarithms, the slide rule, mensuration of circles, ellipses and irregular plane figures, volumes and surfaces of solids, more difficult algebraic expressions than are given in Part i., and the graphic representation of varying quantities. Among noteworthy points in this part may be mentioned the clear account of uses to which a slide rule may be put, the descriptions of planimeters, and the ingenious uses made of squared paper in the section on graphic representation.

The books are full of exercises illustrating the applications to every-day problems of the principles described, and at the end of Part ii. a set of tables of logarithms and anti-logarithms is given, to enable the student to work out problems by logarithms when convenient. It would be too much to say that the books contain an ideal course of mathematics for technical students, but they may fairly claim to provide far more inspiring information and serviceable exercises than can usually be found in text-books designed for use in schools.

Exercises in Natural Philosophy, with Indications how to Answer them. By Prof. Magnus Maclean, D.Sc., F.R.S.E. Pp. x + 266. (London: Longmans, Green and Co., 1900.)

THE ability to deal with quantitative results is an essential qualification of a student of physical science. Laboratory work provides some material for the exercise of this faculty, but it is often necessary to use data obtained by others, and to work out problems other than those which are afforded by the student's own practical work. Dr. Maclean's book contains numerous exercises of this character, covering most of the subjects studied in courses of physical science, and many worked-out examples of typical cases suggesting methods of solution for those which follow. Wisely used, the book will provide teachers with useful exercises in mathematics applied to physics, and will make a convenient supplement to text-books in which such exercises are not given. Many text-books do contain questions upon the subjects dealt with, but even in these cases some good additional problems for solution could be selected from the book under notice.

Tables of useful data and physical constants are printed at the end of the volume.

Memoirs of the Countess Potocka. Edited by Casimir Stryienski. Authorised translation by Lionel Strachey. Pp. xxiv+253. (New York: Doubleday and McClure Company, 1900.)

THESE memoirs cover the period from the third partition of Poland to the incorporation of what was left of that country with the Russian Empire. They deal with episodes—more or less romantic and interesting—in Countess Potocka's career, referring to journeys, Court balls, and Napoleon I., between 1812 and 1820. The authoress died, at the age of ninety-one, in Paris, where her brilliant salon held no insignificant place in the gilded pleasures of the Second Empire. There is little of interest to scientific readers in the memoirs; but one or two incidents referring to astrologers are amusing.

LETTERS TO THE EDITOR.

[The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of NATURE. *No notice is taken of anonymous communications.]*

Inverse or "a posteriori" Probability

THE familiar formula of Inverse Probability may be stated as follows:—

Let the probabilities of a number of mutually exclusive causes or conditions $C_1\ C_2 \ldots C_r$ be $P_1\ P_2 \ldots P_r$ respectively, and the probabilities that if $C_1\ C_2$, &c., are realised, an effect or result E will happen be $p_1\ p_2 \ldots p_r$ respectively; then if E happens, the probability that it happened as a result of C_r is

$$\frac{P_r p_r}{\Sigma P p}.$$

The current proofs of this are unsatisfactory, more especially one based on a theorem of James Bernoulli; for even if the ordinary statements of the principle of this theorem were correct, which must be disputed, the argument by which it is applied to Inverse Probability is demonstrably erroneous.

In consequence of the difficulty felt about the usual proofs, there seems to be a tendency to drop the subject, as unsound, out of mathematical theory.

Now it would not be hard to show that there is no essential difference of principle between problems of Inverse Probability and those of ordinary Probability, and therefore it can hardly be doubted that the former should admit of as accurate mathematical treatment as the latter.

The following is offered as a proof which can claim the same rigour as the theorems of ordinary Probability, and illustrates the identity of principle in both kinds of Probability:—

Let A and B be contingencies which are not independent, then by a known theorem

Prob. concurrence of A and B = Prob. A × Prob. of B if A happens.

Or, as it may be shortly expressed,

Prob. A with B = Prob. A × Prob. B if A.

Similarly

Prob. A with B = Prob. B × Prob. A if B.

$\therefore$ Prob. A × Prob. B if A = Prob. B × Prob. A if B.

$$\therefore \text{Prob. A if B} = \frac{\text{Prob. A} \times \text{Prob. B if A}}{\text{Prob. B}};$$

and this is really our theorem. For put A = C_r and B = E.

$$\therefore \text{Prob. } C_r \text{ if E} = \frac{\text{Prob. } C_r \times \text{Prob. E if } C_r}{\text{Prob. E}}.$$

But Prob. $C_r = P_r$, Prob. E if $C_r = p_r$, and obviously Prob. E $= \Sigma P p$ by a known theorem.

$$\therefore \text{Prob. } C_r \text{ if E} = \frac{P_r p_r}{\Sigma P p}.$$

Another demonstration may be given which, though a little longer, is quite simple.

If the whole number of "equally likely" cases with reference to a given contingency E is b, and the number of these in favour of E is a, then the mathematical probability of E is, of course, $\frac{a}{b} = p$, suppose.

Considered as a fraction, $p = \frac{na}{nb}$, where n is any quantity whatever.

Suppose n an integer, as a fractional value does not here concern us. We may consider each of the original "equally likely" cases as including n "equally likely" sub-cases; and then we can interpret the fraction $\frac{na}{nb}$ as we interpreted $\frac{a}{b}$, and say that there are nb new cases equally likely, and of these na are in favour of E.

Obviously, if x is the total number of equally likely cases, the number in favour of the event or contingency is px. Again, if q is the probability that E happens if C happens, this means that q of the equally likely cases of C's happening are in favour of

E; and so, of course, there must be a total number y of such cases such that qy is an integer.

In the problem before us let P_1, P_2, &c., be reduced so as to have a common denominator b, then P_1b, P_2b, &c., are integers.

Multiply in each fraction P_1P_2, &c., numerator and denominator by n, taking n such that p_1P_1nb, p_2P_2nb, &c., are integers. Put $nb=x$.

Then of x equally likely cases, P_rx is the number favourable to C_r. And, as above, the number of these again favourable to E, is p_rP_rx, that is, the number favourable to E happening as result of C_r (or "C_r if E")$=p_rP_rx$; and the total favourable to E is ΣP_px.

Now, if the event E happens, the total of possible cases, of which one or other must be the true one, is clearly ΣpPx, and by hypothesis none of these cases has any preference over the other, and all are "equally likely;" while the number of them favourable to E resulting from C_r is p_rP_rx. Therefore the probability if E happens that it happens from C_r is

$$\frac{p_rP_rx}{\Sigma pP}.$$

It may be noticed that a proof of the theorem that if A and B are not independent, Prob. A with B = Prob. A × Prob. B if A, which is repeated in edition after edition of ordinary text-books, and so seems to have passed muster, is, nevertheless, erroneous.

The formula is proved correctly for two independent events, thus:—

Let a be the number of cases in which the first event may happen, b the number of those in which it fails; a' the number in which the second may happen, and b' the number in which it fails, the cases for each event severally being supposed equally likely. Each of the $(a+b)$ cases may be associated with each of the $(a'+b')$; thus there are $(a+b)(a'+b')$ compound cases which are equally likely. In aa' of these both events happen; therefore the probability of both happening

$$=\frac{aa'}{(a+b)(a'+b')}=\frac{a}{a+b}\times\frac{a'}{a'+b'}=\text{Prob. first event}\times\text{Prob. second event.}$$

It is then added that the above proof may be applied to two dependent events, for we have only to suppose that a' is the number of ways in which after the first event has happened the second will follow, and b' the number of ways in which after the first event has happened the second will not follow. Now if this substitution be made in the above, the first step of the proof will be "each of the $(a+b)$ cases may be associated with each of the $(a'+b')$ cases; thus there are $(a+b)(a'+b')$ compound cases which are equally likely." But this is impossible. Each of the $(a'+b')$ cases is one in which the first event happens, and therefore none of them can be associated with any of the b cases, because these presuppose that the first event has not happened. The $(a'+b')$ cases, in fact, can only be associated with the a cases out of the $(a+b)$, and thus the total number of the compound cases intended is not $(a'+b')(a+b)$. A proof can easily be given on the lines already indicated.

If P_1P_2, n, and b have the same meanings as before, the whole number of equally likely cases is nb, the part favourable to the first event is P_1nb, and the part of these favourable to the second is p_1P_1nb (as above shown), which is therefore the number favourable to the concurrence of the two events. The probability, therefore, of the concurrence is

$$\frac{p_1P_1nb}{nb}=p_1P_1$$

Certain confusions which often arise in the statement and application of the mathematical theory of probability would be avoided if a clear idea were formed of what is exactly meant by the fraction which is said to represent the probability of an event.

A good statement of the ordinary account of it is given in Todhunter's Algebra: "If an event may happen in a ways and fail in b ways, and all these ways are equally likely to occur, the probability of its happening is $\frac{a}{a+b}$, and the probability of its failing is $\frac{b}{a+b}$. This may be regarded as a definition of the meaning of the word probability in mathematical works."

A definition must not assume and use the notion to be defined. Here probability is defined through cases "equally likely to occur"; but "equally likely to occur" means equally probable, and so the definition assumes the very notion which causes difficulty, the notion of "probability" or likelihood, and of which we require the explanation.

The first thing to settle is the meaning of these "equally likely" cases. Is the equal likelihood a quality in things themselves, or is it something in our minds only? If it is a quality in things it can only mean equal possibility of occurrence or realisation. But if a number of cases, mutually exclusive as intended in the above definition, were in the nature of things equally possible, not one of them could happen. If the claim of any one of them in reality were satisfied, so must the claim of any other, since these claims are equal, and therefore if one happens all must, but by hypothesis if one happens no other can; thus the only possible alternative is that none of them can happen. (It is precisely on this principle that we decide that the resultant of two equal forces at a point, whose directions include an angle, cannot be in any other direction than the bisector of the angle, and that there can be no resultant of two equal forces which act in opposite directions).

The equal likelihood then intended cannot be anything in the nature of things because it is assumed that one of the equally likely cases will happen. It is really only in our minds, when there is an equal balance of reasons for and against two or more events, and due solely to our ignorance, since if we knew which was to happen there could be no such balance and indecision. This is clear if we consider what is the reason why we pronounce one event more likely or probable than another; it is because we think there is more evidence in favour of the one than in favour of the other, however the "more" may happen to be measured. Two events are equally likely to us when we know nothing more in favour of the one than we do of the other—when the state of our knowledge and (it is important to add) of our ignorance, is the same for both contingencies. This view agrees with the actual procedure in mathematical examples. If a bag contains n balls, and one is to be drawn "at random," there are said to be n equally likely cases, that is, each of the n balls is equally likely to be drawn. Clearly this only means that as we don't know how the hand is going into the bag, we have no information in favour of the drawing of any one ball as compared with any other, and no information against the drawing of any one ball as compared with any other.

"Equally likely" cases then being such that owing to our ignorance the evidence in favour of any one is no greater or less than the evidence in favour of any other, the meaning of the definition of probability above criticised is evident; it is not a definition of probability, but it is the definition of a certain way of measuring evidence.

We are entitled to say that one event is more probable than another when the evidence before us, being decisive for neither, that in favour of the one seems to us, according to some standard of measurement, greater than the evidence for the other. Now what the mathematical analysis does is not to alter the ordinary meaning of "probability" at all, but to find a standard for the measurement of the more and less in evidence.

The whole possibility before us in any given contingency is divided into a number of cases, "equally likely" or "equally possible," in the sense that they are equal from the point of view of the evidence in favour of each of them; then if one event has more of these equal possibilities in its favour than another, it has in this sense "more" evidence in its favour, and so in accordance with the usual meaning (as above described) of "more probable," is more probable than the other. And here the "more or less" in the evidence is not a mere "more or less," but has a definite numerical measure. The evidence being, so to speak, divided into equal units, the strength of the evidence in favour of a contingency is measured by the number of these units in its favour. Thus if the total of equal possibilities, one of which must happen, for the events A B and C is n, of which a involve A, b involve B and c involve C, the comparative strength of the evidence in favour of A, B and C respectively is measured by the ratios $a:b:c$, while the strength of the evidence of A, B and C respectively, as compared with the evidence for one or other of them happening (which is certain), is, on the same principle, measured by the ratios $\frac{a}{n}$, $\frac{b}{n}$ and $\frac{c}{n}$.

If, then, we symbolise the strength of the evidence for A, B and C by $\frac{a}{n}$, $\frac{b}{n}$, and $\frac{c}{n}$, and similarly that for one or other

of them happening by $\frac{n}{n} = 1$, these quantities have to one another the ratios required. We then arrive at the true meaning of the fraction which is said in mathematics to be the "probability" of a contingency; and much confusion might be avoided if we called the fraction, not the "probability," but the "*modulus of the evidence*," and the so-called equally likely cases not "equally likely" but "*equi-evidential*," or by some more convenient name conveying the same idea.

But it must be insisted that the above is only one way of measuring the evidence, and is not applicable to all cases. Indeed, the more important matters of daily life usually do not admit of it, for there are qualitative differences in strength of evidence which cannot really be measured quantitatively, and that is why the application of mathematical probability to the testimony of witnesses is so obviously futile.

The solution of every mathematical problem in probability is in the last resort only the finding of a modulus of evidence, in the ratio of the part of the whole number of equi-evidential cases which involve a given contingency, to the whole number of such cases; and with the finding of the modulus the strictly mathematical work ends. Mathematics, as such, has nothing to do with the inclination in our minds to expect the event for which the modulus of evidence is greatest (or "the probability" greatest), or the inclination, when some practical step has to be taken, to act on the hypothesis that the event will happen for which the evidence to us seems strong.

Unfortunately, however, there is too often a tendency to confuse the mathematical measure of the mere state of our minds with the measure of something in reality; and this produces various mistakes—*e.g.* the inclination to expect that the actual proportion of the occurrences of the event will tend to conform to the proportion represented by the mathematical probability, *i.e.* conform to a formula of our ignorance. This is an insidious fallacy, and we are not unlikely to fall into it in one form when we have escaped it in another; the mistake of supposing the mathematical probability could be confirmed by actual observation belongs to the head. The attempt to regulate betting by mathematical probability is another instance of the fallacy of confusing the subjective with the objective. The truth is that an observed average may be made the basis of a mathematical "probability" or modulus of evidence, by a process which could easily be explained; but though a "probability" may be based on an average, an average can never be based on a "probability."

J. COOK WILSON.

Instruments of Precision at the Paris Exhibition.

I WAS glad to see your appreciative article upon the German instruments of precision at the Paris Exhibition, in which you refer, among other things, to the splendid catalogue which was freely given away to any one who showed any interest and desired to have a copy.

As a member of the Jury of Class 15, I naturally was led to duly appreciate both the German productions and their catalogue, and fearing that this valuable record might too soon become inaccessible, I asked Dr. Drosten if he would send a copy to the Science Library of the Victoria and Albert Museum, so that it might be permanently available for many who might wish to see it. This he most willingly did.

If copies are becoming scarce, it would be more to the point that public libraries attached to scientific institutions should have them than that they should run the risk of being buried and lost in private hands.

C. V. BOYS.

A New Form of Coherer.

DURING the past eighteen months I have been called upon to demonstrate the principles of wireless telegraphy in connection with my regular lecture courses, and now and then, while wireless telegraphy was still the latest scientific novelty, in popular lectures.

For the latter purpose it was necessary to have the receiving apparatus as simple as was possible, compatible with a moderate sensibility and regularity of action.

I found the Marconi arrangement, consisting of the separate instruments, coherer, relay and decohering devices, to have the disadvantage, for my purpose at least, of requiring long and careful adjustment each time the apparatus was set up.

It occurred to me that if the functions of the three instruments could be performed by a single instrument, an easier adjustment would result.

This would, perhaps, be of no advantage in the case of a permanent set up, but would be of considerable advantage in apparatus designed for the purpose of demonstration.

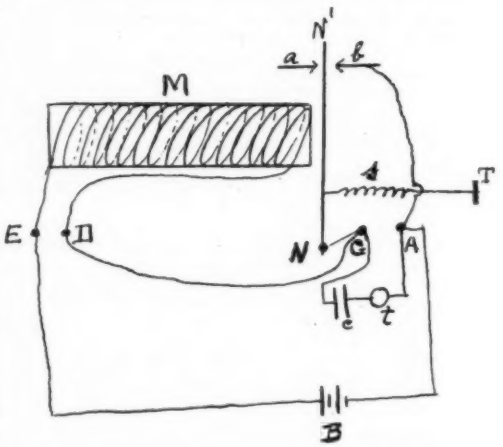
By a slight modification, which need not be permanent, an ordinary telegraph relay of moderate sensibility may be made to serve the purpose of the coherer, relay and decoherer of the Marconi arrangement.

The ordinary telegraph relay is shown in the accompanying sketch.

M is the electromagnet, which in most cases is mounted so that its distance from the armature, NN′, can be varied by a slow-motion screw, E and D are the main circuit terminals, A and C the terminals of the relay circuit, C is connected with the armature NN′, and A is connected to the stop *a* when the instrument is used as a relay. T is a screw connected to NN′ by a spiral by means of which the pressure of the armature on the stop *b* may be varied.

Usually the stop *b* is of hard rubber, and *a* and *b* may be interchanged. If this interchange is made and if C is connected with D, then the battery B will send a current through the electromagnet M and the loose contact N′*b*.

The tension in the spiral, *s*, and the position of the electromagnet may be adjusted so that no current flows, on account of the very high resistance of the loose contact (coherer) N′*b*. If this resistance is lowered by electromagnetic radiations, then the



current through the electromagnet rises and NN′ is attracted towards M and the circuit at N′*b* is broken. The spiral *s* draws NN′ back into contact with *b* and the instrument is ready to again respond to electromagnetic radiations. The adjustment of M and T are easily made, and once made the coherer works very steadily.

The motion of NN′ is too slight to be visible or to close an auxiliary circuit with a sounder, but if a telephone, *t*, in series with a condenser, *c*, is put in parallel with the coherer (*i.e.* across A C) the make and break of N′*b* are clearly audible.

If a "loud-speaking" telephone or a telephone with a manometric flame are used, the make and break can be made audible or visible to an audience.

If the distance between sending and receiving stations should make it necessary, C can be earthed and A connected with a vertical wire. It is well to have the resistance of the electromagnet as low as is compatible with moderate sensibility in order that the normal high resistance of the coherer shall form the major part of the total resistance in series with the battery.

In adjusting the contact N′*b* it is convenient to set M and T so that the armature NN′ vibrates automatically, and then relieve the tension in the spiral *s* until the automatic vibration just ceases.

When this adjustment is made, a "dot" signal from the sending station gives a single "tick" in the telephone—a dash gives a series of ticks.

I have never attempted to telegraph over a distance exceeding

several hundred feet, using the form of coherer described, and, therefore, I am unable to compare its sensibility with that of the usual form.

Undoubtedly it would prove to be less sensitive, but for use over a moderate distance it forms a convenient instrument for the purpose of demonstration. AUGUSTUS TROWBRIDGE.

University of Wisconsin, U.S.A.

Secondary Sexual Characters and the Coloration of the Prong-buck.

THE weak spot in Mr. Cunningham's argument (NATURE, November 8, p. 29) lies in his believing it to be conceded that secondary sexual characters which are the outcome of male katabolism need no explanation by the theory of sexual or of natural selection. Starting with this assumption, he points out that, since these characters are often not developed, male katabolism does not exist in such cases, or exists without producing any visible effects. He therefore rejects male katabolism as the cause of the variations and introduces in its stead "nervous and muscular activity" and "the habits of life and external conditions.

Whether Mr. Cunningham's hypothesis is an improvement upon that of Geddes and Thomson or Wallace may be doubted; and, so far as his views are intelligible to me from the brief epitome his letter contains, they labour under the disadvantage of involving an acceptance in the Lamarckian doctrine and the transmission of acquired characters—problems which, seductive and important though they be, are as yet insufficiently supported by evidence and, whether true or false, stand aside from the Darwinian theory, neither refuting nor confirming it.

After all, "male katabolism," "metabolism" and "physiological activities" are in this connection merely names assigned to the unknown primary cause of certain male characters, and, as such, are nothing but imposing substitutes for the "vital force" of the pseudoscientific realists.

Setting on one side the question of the initial cause of variation, I am quite unable to agree with Mr. Cunningham that secondary sexual characters may reach a high standard of perfection and be maintained in a state of stability by "physiological processes" without the controlling influences involved in the struggle for existence. Sexual variations, once started, must fall, like other variations, under the influence of external conditions; those which are harmful will be eliminated; those which are beneficial selected and preserved. Therefore, considering the diversity of the conditions under which species live, the needs that have to be satisfied, the enemies that have to be avoided, it is no matter for surprise that, even in the males of closely allied forms, the sexual characters vary in degree of manifestation, are sometimes suppressed, sometimes developed; or, taking the particular case Mr. Cunningham mentions, that the nigrescence of the bull kudu and nilghaie may, as I have suggested, be checked for purposes of concealment in the one and emphasised as an ornament or advertisement in the other.

One or two points in Mr. Cockerell's criticism of a footnote (NATURE, October 15, p. 58) call for comment. His suggestion that Mr. Wallace cites the prong-buck as an instance of recognition-marks in the sense in which these terms were employed in my article is inexact; and his opinion that I completely overlooked the point of a theory I was not discussing is, I can assure him, erroneous. Moreover, in spite of his incredulity, I venture to repeat that the prong-buck, with its white belly and darker upper side, *is* an illustration of Thayer's principle. That its patterns are to be explained exclusively on this principle I did not assert. With regard to Mr. Cockerell's reasons for rejecting the view that the prong-buck is procryptically coloured, I would commend the following facts to his consideration. Zebras and giraffes can be "seen from afar off in herds," they seek "safety in flight," and they have the same "necessity for keeping together when in flight" that the prong-bucks have. Nevertheless, these animals are known to be procryptically coloured, though the fact is by no means always evident to those who "have had the pleasure of seeing them in their native wilds." R. I. POCOCK.

November 18.

A New Race of Musk-Ox.

MR. ROWLAND WARD has on view at his establishment in Piccadilly a mounted adult male and female musk-ox from East Greenland, which differ from the ordinary form in having a large whitish patch on the face, as well as in certain other details of coloration. They may be made the types of a new race, under the name *Ovibos moschatus wardi*. The female was recently exhibited at the Zoological Society. R. LYDEKKER.

Harpenden, December 10.

The Optics of Acuteness of Sight.

IN reference to the letter of Mr. Percival in your issue of November 22 (p. 82), concerning acuteness of vision, it is interesting to determine the power of resolution of the eye considered as a lens merely, according to the well-known rule,

$$\theta = \frac{\lambda}{A} \times 2{\cdot}44.$$

Where θ is the angular diameter subtended at the second nodal point by the first dark ring of the diffraction image of a distant point, A is the aperture of the lens, and λ is the wave-length of the radiations (supposed homogeneous) from the distant point.

Taking A for the eye as 4 mm., and λ as 0·000589 mm. (yellow light) the value $\theta = 1'2'$ is obtained.

Hence the diffraction image of a luminous point on the retina may be taken as rather less than 1′ in angular diameter (the brightness of the diffraction disc rapidly decreasing towards the first dark ring).

It would thus seem that, should any *considerable* superiority of acuteness of vision exist among savages the cause should be looked for in the aperture of the iris, as well as in greater detail of the retina. F. TWYMAN.

54, Haverstock Hill, London, N.W., November 26.

Euclid i. 32 Corr.

WITH reference to Mr. Allman's letter in NATURE of November 29, the following will, I think, be of interest.

In Proclus' (411–485 A.D.) commentary printed at the end of the Editio Princeps of Euclid (Grynaeus-Bâle, 1533 A.D.) these two corollaries are given:—

(1) The sum of the interior angles of any polygon is equal to twice as many right angles as the polygon has sides less two.

(2) The sum of the exterior angles of any polygon is equal to four right angles. STAM. EUMORFOPOULOS.

33, Gloucester Square, Hyde Park, W., December 3.

A PLEA FOR THE STUDY OF THE NATIVE RACES IN SOUTH AFRICA.

IN a recently-published work Dr. P. Topinard makes the statement that ethnography is cultivated in England because it leads to a knowledge of the natives, and thus prepares the means of turning them to account. This distinguished French anthropologist appears to have permitted his dispassionate judgment to have temporarily forsaken him. Alas! ethnography is but little cultivated in this country, and it may be said to be almost entirely neglected by our Government. It was to take away this reproach in some measure, and to seize the present opportunity in South Africa, that led Mr. E. Sidney Hartland, the President of the Folklore Society, to read before the Anthropological Section of the British Association at Bradford a very carefully considered and temperate paper, "On the Imperfection of our Knowledge of the Black Races of the Transvaal and Orange River Colonies."

Mr. Hartland stated that on the pacification of these colonies one of the first problems confronting us would be the management of the native black population. This led to the question, What did we know of the African races of these provinces? It must be confessed that we knew very little. Our hunters had hunted big game through the land; our missionaries had taught the natives; our traders had traded with black and white; our soldiers had fought in the country, and during the last twenty years mining adventurers had exploited the mineral products. None of these, except the missionaries, had had any real interest in the natives; consequently, few of the others had recorded anything of value

concerning them. The records by the missionaries had been for the most part scrappy, and, from a scientific point of view, not to be implicitly trusted. But the blame for this did not rest entirely on the missionaries. The gap which the missionaries found between the savage mind and their own was unexpectedly wide, and this rendered it difficult for them to understand the natives, as well as for the natives to understand them. Moreover, what the missionary learnt of the native manners and customs he did not think it becoming to publish. Moffat had said that a description of these things would not be instructive or edifying. In the interests of science and government, it was much to be regretted that he and other missionaries had taken this view. Later missionaries had given us more information; John Mackenzie and Livingstone's books contained much of value, but were incomplete, and not always exact. One other reason of our defective knowledge of the customs of the black people was that, until the country was settled by the Boers, there was a state of intermittent warfare, which frequently resulted in the extermination of whole tribes.

There was among the various tribes a general similarity of institutions, customs and belief, but this similarity was by no means uniform. In the Umzimkulu district of Kaffraria all additions to, and alterations of, laws were made by the chief and councils at Great Place. Among the Galekas, Fingoes and Basutos, laws could be altered after the fashion familiar to us in England as "Judge-made law." Conservative as the natives were, the fact that there were recognised ways of making changes implied that such changes were effected, and that differences existed. In the matter of theft the punishments inflicted varied among the different tribes. Property stolen from the chief was punished more severely; in Bechuanaland restitution was required to be made. It was also pointed out that there were difficult questions respecting marriage and inheritance. The prohibited degrees seemed to be in one direction much wider than with us. In general throughout South Africa all blood relationship, which was recognised as such, was an absolute bar to marriage. Among one tribe such a marriage was dissolved, and a heavy penalty inflicted on the man. Among another tribe the only question was how much the man was willing to pay. Some tribes permitted a man to be married to two sisters, both living. Most of the tribes were polygamists. This fact rendered family arrangements very complex, and most of the questions coming before the courts were questions of inheritance. Wives of a native polygamist were not equal in rank. There was a great wife and a right hand wife, and most of the tribes recognised a left hand wife. Among few tribes could a woman inherit property. The Basutos were among the few. In general women, though not themselves property, were in a state of tutelage, and so incapable of either holding or inheriting property. It was easy to understand that the large number of tribes in South Africa would furnish an interminable example of difference of custom. Cases of theft often came before the courts; in some districts cases of inheritance were very common; while cases relating to marriage were always important, because status and inheritance depended on marriage, and such questions were frequent subjects of judicial decision.

One of the modes of oppression of natives in the Transvaal, Mr. Hartland proceeded to observe, had been the refusal to recognise any of their marriages. This was a policy we should be compelled to reverse. In order to do so we must start by informing ourselves what marriages were regarded by the natives of each tribe as legal, lest in our hasty zeal for justice we inflicted injustice. This information could only be obtained by careful inquiry on the spot. A bride-price was usually paid for the bride, but it was not always given. In nearly all tribes, however, it was a necessary incident of the most honourable form of marriage. A bride for whom no price had been paid felt very much as in this country a strict Churchwoman would feel if she were forced to be married at a registrar's office. A wife for whom no price had been paid would be reminded of the fact every time she quarrelled with her neighbours or with one of her fellow-wives, or even with her husband. Twenty years ago the Cape Government came to the conclusion that it ought, both for legislative and administrative purposes, to learn something about the native customs and institutions. The report of that Commission was perhaps the most valuable document we possessed on the black races of South Africa, and must form the basis of any inquiry our Government might make into the customs of the native races of the Transvaal and the Orange River Colony. One of the difficult problems discussed by the Commission was that of the bride-price, known as *Lobola* or *Ukulobola*, and the question was whether the transaction was a bargain and sale of the bride, and, therefore, according to our law, immoral, or, if not, what it was? A Church missionary of twenty-three years' experience described it as being the "direct sale of the girl in its purest state," and a Wesleyan minister said it was the "root of heathenism." On the other hand, Archdeacon Waters and Dr. Calloway, Bishop of St. John's, had, however, expressed their opinion in favour of the custom, holding that the payment was a pledge for the good treatment of the woman, and a pledge of her good conduct.

It was established by the Commission that the custom of *lobola* was not a purchase of the bride, but a substantial guarantee for her good conduct and good treatment. But the inquiry showed that Europeans, even if experienced in native ways, were often incapable, from prejudice or ignorance, of penetrating below the surface to the real meaning of a custom. Some who gave evidence could not distinguish between slavery and tutelage, and in their view every Roman matron would have been a slave.

It must be remembered that we could not civilise the savage all at once, and with a veneer of civilisation he would be more dangerous than before, for he would accept only its sweets and reject its bitters. The subject of beliefs was not less important than that of customs. We ought to govern the native races according to their own laws, and not by ours. We should remember that if we had so much difficulty in understanding their laws, it was no wonder they had similar difficulty in understanding ours. They were, as a missionary told the Commission, so much attached to their customs, and their customs were so much a part of themselves, that they could not imagine any others. An accurate study of the native customs, institutions and beliefs was an urgent necessity both for missionaries and for purposes of government.

Now that the natives had come under British rule the opportunity ought to be taken to register their condition at the time, not less for scientific than for administrative reasons. The happiness of the natives depended on the way we treated them, and if we were ever to raise them to civilisation—which it must be the great object of every civilised Government to do—we must bear in mind that that could only be done gradually, and by deferring, as far as practicable, to their prejudices, and leading them gently, but gradually, from savagery to that condition of life in which we found our happiness, and in which it was to be hoped they would find theirs.

It is to be hoped that Mr. Hartland's plea will not be ignored by Her Majesty's Government, but that as soon as the condition of the Transvaal and the Orange River Colony should permit, and prior to any legislation affecting the natives, a commission should be appointed to

inquire (*a*) into the customs and institutions of the natives of those States, and (*b*) into the relations between the natives and European settlers, with power to make recommendations for the purposes above referred to; such commission to consist, so far as possible, of persons familiar with native life in South Africa, and, in addition, of at least one person, unconnected with South Africa, of recognised eminence in the study of savage customs and superstitions in general. A. C. HADDON.

ZOOLOGY IN THE WEST INDIES.

WE called attention in our "Notes" of November 29 (NATURE, vol. lxiii. p. 112) to a rumour that the curator of the museum of the Institute of Jamaica, who for close upon six years has laboured with marked success, is about to relinquish his office in the spring; and the receipt of confirmatory evidence forces upon us a comment upon the situation. The gentleman in question was originally appointed in 1896 for a period of three years, which was renewed in 1899, and during the whole time he has been most assiduous in both the ordinary curatorial and the scientific duties of his office. Under his charge the collections have grown, and by the renewal of old exhibits, and the incorporation of new ones, with a thorough rearrangement of the whole, they have become so materially improved and attractive as to have merited the cordial approval of expert visitors from the home countries and the United States of America. In pure science he has done more; for, while his predecessors were largely content with the mere superficial study of insects, birds and molluscs, he, covering a wider field, has done admirable work in both zoology and anthropology—in the study of the resources of the surrounding sea and of the aboriginal remains on land. He has produced a series of memoirs on the indigenous sea-anemones and coral organisms, which rank high in contemporary zoological literature, and which, as will be evident from the brief *résumé* of his results, which we published in the afore-mentioned note, have done much to clear up a great deal that is perplexing in the study of these organisms. When it is added that the work has necessitated his journeying afield, and that the climatic conditions render research of the kind on modern lines especially difficult, his threatened removal becomes still more mysterious.

Necessity for retrenchment is the alleged cause of it, and by that we presume is meant desire for relief from taxation. If so, the action does not tally with the fact that but a few weeks ago we received, from an authoritative source, a request for advice upon a scheme based on the belief that it might be possible ere long to obtain laboratory accommodation for marine biological work in the Island, in connection with the erection of some hospital buildings in course of construction. The later intelligence which reaches us indicates a sudden change of front for which we desire explanation. To dispense with the services of a curator would be to waste the labours of years, and to bring into reproach an institution now becoming universally recognised as a centre of enlightenment and culture.

From reports to hand, a suspicion arises that the zoological work, as at present carried out under the auspices of the Institute, is not deemed sufficiently economic or adapted to the precise requirements of the island; and that the failure of a recent attempt, on the part of the Caribbean Sea Fisheries' Development Syndicate, to test the resources of certain shallows and banks in the neighbouring seas by means of trawls and long lines, may have had something to do with the situation. If this be so, we can only express our surprise, for both the area explored and the methods employed were wholly inadequate. Assuming the economic desire, we would point out that the curator of the Jamaica Museum has been by no means neglectful of that phase of his opportunities, and that having recently been commissioned to report upon the Edible Echinus or "sea-egg" of the Barbadoes, in his reply—an *interim* report, now in circulation—he wisely advocates the determination of its life-history and recourse to artificial propagation and restocking.

Assuming that mere impecuniosity is the real cause of the trouble, we would recommend an appeal to the Home Government and the Colonial Secretary for immediate relief; and the advisability of an affiliation of the establishment with either the recently founded Imperial Agricultural Department, of which the headquarters are at the Barbadoes, or with some other existing institution of an authoritative kind. The time has passed at which work in marine zoology can longer be left to the caprice of mere local administration, and persons content only with an immediate *quid pro quo*. Experience shows that the scant success which has attended some of the marine zoological work of the past has been due to lack of coordination in observation. What we require for the future, and to ensure that success which even the economist desires, is more, and not fewer, marine observatories, and that these shall be so placed that collective work, properly coordinated, shall be possible over wide areas. Not until every colony having a sea-board, and till at appropriate points round every coast-line there shall be employed a marine zoologist who is a fishery expert, and who shall be provided with a laboratory, a steamboat, a full set of apparatus, and, if possible, a couple of trained assistants, can the desired result be hoped for. We want, and must have, marine stations at all desirable places, and to discourage one already in the making and doing good work is but to court failure and lessen the only chance of success.

As for the Colonies and their marine zoological and museum work, we would fain see the several existing establishments devoted to these placed under the advisorship of the authorities of the British Museum of Natural History, in the manner in which those in botany have so long been under the guidance of the officials at Kew, subject to their power of appeal to the Home Government; and we feel assured that were this already the case the action we herein deplore would never have come about.

Nearly eight years ago zoologists at home, headed by Huxley, directed attention to the resources of the West Indian seas and the pressing necessity for their investigation; and the work which has emanated from the museum of the Jamaica Institute has largely realised their expectations. The curator of that museum, moreover, during the period he has held office, has cultivated a healthy alliance with the authorities of the Johns Hopkins University and the members of its Biological School, foremost among marine zoologists of the North Atlantic, and this has already been productive of mutual gain and cooperative work in the intervening ocean. We now know that materials of prime importance abound in the Jamaica sea, and in the curator of the Jamaica Museum there lives a man, now familiar with these, competent to investigate with advantage both their scientific and economic aspects. His work, upon which we have commented, has been performed with the fullest sympathy and support of the Board of Governors of the institution. His retirement would be followed by their resignation, and chaos would ensue. The proposal to abandon the curatorship of the museum of the Jamaica Institute is retrogade, and it must not be if we, the proud colonisers of the world, are to retain our prestige.

NOTES.

THE retirement of Mr. Charles Whitehead from the position of the Technical Adviser to the Board of Agriculture has led to a reconsideration of the means by which the Board obtain technical advice on questions relating to agricultural botany and economic zoology, and it has now been arranged that the scientific and expert assistance required by the Board in connection with these subjects will be furnished respectively by the Royal Botanic Gardens, Kew, and by the Natural History Departments, South Kensington.

THE Paris correspondent of the *Times* states that at the sitting of the Academy of Sciences on Monday M. Becquerel, whose father and grandfather were also men of science, was warmly congratulated on having received the Rumford medal of the Royal Society. The Academy also elected, by forty-six votes to ten, M. Painlevé in the section of geometry to the seat left vacant by M. Darboux.

DR. ALLAN MACFADYEN, director of the Jenner Institute, has been elected Fullerian professor of physiology at the Royal Institution.

BY a decision of the House of Lords, the Institution of Civil Engineers has been exempted from payment of the Corporation Tax (1894). In view of this fact it is submitted that the Royal Colleges of Physicians in London and Edinburgh may reasonably claim similar treatment; and we learn from the political notes in the *Times* that an attempt is being made by Sir John Tuke to induce the Chancellor of the Exchequer to concur in this view. The especial hardship in this case is that, notwithstanding the important part played by the two colleges in administering and regulating medical education and examination, and in maintaining laboratories for original research, and the obligation upon each Fellow to pay a stamp duty of 25*l.* on election, there will be five years of arrears to make up if the authorities persist in their intention to levy the tax.

THE following are among the lecture arrangements at the Royal Institution, before Easter:—Sir Robert Ball, six lectures (adapted to young people) on great chapters from the book of nature; Prof. J. A. Ewing, six lectures on practical mechanics (experimentally treated); Dr. Allan Macfadyen, four lectures on the cell as the unit of life; Dr. Arthur Willey, three lectures on the origin of vertebrate animals; the Right Hon. Lord Rayleigh, six lectures on sound and vibrations. The Friday Evening Meetings will begin on January 18, when a discourse will be delivered by Prof. Dewar on gases at the beginning and end of the century. Succeeding discourses will probably be given by Prof. G. H. Bryan, Prof. J. J. Thomson, Sir W. Roberts-Austen, Mr. W. A. Shenstone, Dr. Horace Brown, and others.

TWENTY-THREE papers, several of them of a highly important character, were read at a meeting of the U.S. National Academy of Sciences, held at Brown University, on November 13-14. Among novel subjects of general scientific interest brought before the meeting we notice the following:—An account of the study of growing crystals by instantaneous microphotography, by Prof. T. W. Richards; stereographic projection and some of its possibilities from a graphical standpoint, by Prof. S. L. Penfield; report of progress made with the Echelon spectroscope, and the spectrum of sodium in a magnetic field, by A. A. Michelson; the explanation of inertia and gravitation by means of electrical phenomena, by Prof. H. A. Rowland; male preponderance (Androrhopy) in Lepidopterous insects, by A. S. Packard; exhibition of certain novel apparatus; a wave machine; an expansion lens; a recording system of two degrees of freedom; a tube showing coloured cloudy condensation, by Dr. C. Barus; recent observations of the planet Eros, by Prof. E. C. Pickering.

SOME valuable additions have recently been made to the equipment of the observatory of Salò, in Lombardy. They include several recording meteorological instruments, different forms of seismoscopes, a great seismometrograph, and a limnograph for registering the seiches in Lake Gardo, the observatory being situated on its western shore.

A DOUBLE explosion, resulting in the loss of three lives, occurred on November 28 at the Smokeless Powder Works at Trimley, near Ipswich; the first in the mixing house, where 125 pounds of explosive material were being prepared, and the second in the drying house, which contained a large quantity of gun-cotton. The entire factory, consisting of a series of isolated sheds and a boiler house, was almost razed to the ground, the *débris* being scattered over the adjoining fields. The concussion was felt at Ipswich and Rendlesham House, near Wickham Market, which are about eight and twelve miles respectively from the scene of the disaster, and also, it is said, at other places outside a radius of fifteen miles.

THE seismological observatory of Quarto-Castello, near Florence, is one of the most completely furnished so far as regards apparatus provided with mechanical means of registration (see NATURE, vol. lxii., p. 200). Several instruments have been added during the past year, and the older ones have received some improvements in detail. Mr. D. R. Stiattesi, the director of the observatory, has just printed his second seismographic bulletin, that for the year November 1, 1899, to October 31, 1900. This valuable pamphlet contains details of the records by the different instruments of no fewer than 135 earthquakes. Its publication within a month of the date of the last entry is a feature worthy of imitation. Dr. G. Pacher has also issued the second part of the seismographic bulletin of the University of Padua for March 19 to June 30, 1899. The records at this observatory are obtained by means of the microseismographs designed by Prof. G. Vicentini, more than half (sixteen out of twenty-nine) being those which are characteristic of distant shocks.

IN our Norwegian contemporary, *Naturen*, published in Bergen, Dr. Hans Reusch, director of the Geological Survey, notices some geological investigations of great interest which have been made by a young scientific Icelander, Mr. Helgi Pjetursson. According to this observer, Iceland shows that the Glacial period has had several subdivisions separated from each other by ice-free periods, as has been demonstrated to be the case in the Alps and other similar regions.

Dr. REUSCH draws attention in *Naturen* to the changes of level that have taken place in Iceland in recent geological times, viz., since the Ice age. He points out that on a hydrographic map of the North Atlantic Ocean there is shown a submarine ridge under shallow water, which stretches from the Faroe Isles to Iceland and thence over to Greenland. North and north-east of it lies the deep Norwegian Sea. During the Norwegian Atlantic expedition there were found, strewed over the bottom, shells of Arctic mollusca, which at present live in a considerably colder climate and in much shallower water than that which prevails in the Norwegian Sea. Mr. H. Friele directed attention to that fact, and he suggested that the shells had been carried out to the deep sea by drifting ice. It ought, at the same time, to be remembered that Prof. G. O. Sars had found, off the Romsdal coast, in very deep water, shallow water shells and rolled pebbles, and he inferred that this was evidence that sinking of the sea-bottom had taken place there. In 1896 the Danish Ingolf Expedition investigated the sea-bottom between Ian Mayen and Iceland. In examining the dredged material, Herr A. S. Iensen made the observation that almost everywhere over the bottom of the deep ocean lie shells of dead molluscs of well-known

shallow water forms side by side with deep water forms. It was very remarkable to dredge up, from depths of 500 to 1300 fathoms, *Yoldia arctica*, which now lives at Spitsbergen and in the Kara Sea at depths from 5 to 100 fathoms. Dr. Reusch suggests that these remains of Arctic life-forms cannot have been carried there by drifting ice, but that the sea-bottom, in comparatively recent times, during the Ice age, must have been much nearer the sea-level than now. At that time the Arctic shallow water forms must have lived there *in situ*, then a sinking of the sea-bottom has taken place which can be estimated at not less than about 2500 metres. It is easy to see that these results of the Danish naturalist have an important bearing upon the phenomena of the Ice age.

ELECTRO-CHEMICAL sciences and industries will shortly have their own technical journal. The *Electro-Chemist and Metallurgist* will make its appearance on January 15, 1901, and will do its best to keep chemists and manufacturers informed as to the progress of knowledge of electro-chemistry and practical developments. The journal will be published monthly by Messrs. Sherard Cowper-Coles and Co., Ltd., Westminster.

A MONTHLY record of the progress of anthropological science is about to be established by the Anthropological Institute, and will appear under the title of *Man*. Its contents will include contributions to physical anthropology, ethnography and psychology; the study of language, and the earlier stages of civilisation, industry and art; and the history of social institutions and of moral and religious ideas. These various branches of study will be treated more fully, in proportion as they are less adequately provided for in existing periodicals. Special note will be taken, throughout, of investigations which deal with the origins and the earlier stages of those forms of civilisation which have eventually become dominant, and of the races among which they have arisen and developed.

AT a meeting of the Scientific Committee of the Royal Horticultural Society, on December 4, a curious "Weeping Chrysanthemum" was shown. The plant was one of eleven seedlings from a cross raised by Mr. Austen, Ditting Court, Maidstone. The peculiarity of all eleven plants consisted in the downward geotropic direction of the branches, which were bent like those of a Weeping Ash, but upturned heliotropically at the ends, where flowers are produced. Dr. Masters showed a drawing of seedlings of Leucodendron raised by him and presenting a curious outgrowth from the caulicle (hypocotyl), similar to that in the Pea.

THE U.S. *Monthly Weather Review* for July last contains an interesting article on fog studies on Mount Tamalpais, a little to the north of San Francisco, by Mr. A. G. McAdie. The paper is accompanied by photographic illustrations of (1) fog over the Golden Gate, taken from the Weather Bureau Observatory on the above mountain; (2) fog streaming in from the Pacific; and (3) valley fog, originally sea fog, but augmented by radiation about sunset. The locality is well chosen for the study of the formation of fog; from May until September, during which time scarcely any rain falls, great banks of fog invade San Francisco with clock-like regularity every afternoon, while it is known that at some 1500 feet above the air is clear, and 20° or 30° warmer. The mean relative humidity on the mountain is 59 per cent., while at San Francisco it is 83 per cent. It is worthy of note that during the summer of 1899 a difference of temperature of 44° was recorded within so short a distance as 25 miles between Mount Tamalpais (the warmer station) and Point Reyes. The Weather Bureau maintains a regular fog service at San Francisco, and the extent and character of the fog in the roadstead and neighbouring localities are made known by means of frequent reports.

WE have received a copy of the Report of the Meteorological Commission of the Cape of Good Hope for the year 1899. There have been in operation during the year (or some part of it) about 450 stations, including the observatories at the Cape and at Kenilworth, near Kimberley; of this number 364 stations observe rainfall only. About 23 per cent. of the returns are incomplete, owing chiefly to the effects of the war. The observer at Kenilworth (Mr. Sutton) continued his observations all through the siege of Kimberley, although this station was situated outside the lines of defence, and, owing to his courage, the important records for the year are unbroken. It has been found that the old pattern Stevenson thermometer screen formerly used in this country does not sufficiently protect the instruments from the intense radiation in that part of the world, and that, except during strong winds, any two spots inside the screen seldom had the same temperature. The screen adopted is an enlarged one, designed by Mr. C. L. Wragge; it is, like the new pattern Stevenson screen, provided with a double roof, with three overlapping boards in the base of the screen, and it appears to be much better adapted to the conditions prevailing in South Africa. Some interesting notes from the Report of inspection of the stations are given by Mr. C. Stewart, Secretary to the Commission.

IN the annual report of the Imperial Bacteriologist of India (Mr. Lingard) for 1899–1900, we regret to learn that a large portion of the valuable laboratory specimens, records and library was destroyed by fire last year. An outbreak of a disease clinically resembling glanders, but differing from the latter (*a*) in not reacting with mallein, and (*b*) in the absence of the *Bacillus mallei*, is described and identified as "lymphangitis epizootica" of Rivolta, due to a protozoon parasite. The greater portion of the report deals with experiments conducted with regard to rinderpest. Animals vaccinated by injections of blood and of bile of diseased beasts were found to be fully protected nearly two years after the inoculations. Animals may be inoculated with increasing amounts of virulent blood, and then yield a serum which will protect against rinderpest, and a rapid method of immunising is described. The immunity produced by an injection of serum is, however, transient; and in order to produce a lasting or "active" immunity, recourse must be had to inoculation with virulent blood. But this is a risky operation, a considerable proportion of the beasts so inoculated dying; and, in order to avoid this, a preliminary injection of the immunising serum is given followed by the virulent blood. The amount of the serum used must be small, sufficient to ward off serious symptoms but not to prevent a transient illness; otherwise the immunity would be "passive," and not a lasting one.

A NOTABLE instance of "discontinuous distribution" is recorded by Prof. W. M. Wheeler in the *American Naturalist* for November. It appears that in 1886 a very remarkable and aberrant arachnid was described from Sicily under the name of *Koenenia mirabilis*; this creature showing a superficial resemblance to the whip-scorpions, although representing an entirely distinct group by itself. During the past spring Prof. Wheeler collected in Texas an arachnid which, on examination, proved to be specifically identical with the Sicilian form. In Sicily, Koenenia was found in association with species of the genera Japyx, Campodea, Scolopendra, and Pauropus; and, with the exception of the last, it occurs in Texas in company with representatives of the same genera. The European and American species of these genera are, however, distinct. Prof. Wheeler cannot admit that the Koenenia was introduced, and he regards it as the survivor of a very ancient fauna. An analogous case is presented by the occurrence of *Proiapyx stylifer*, a primitive thysanurid insect, in Liberia and Argentina.

IN the *American Naturalist* Prof. Wheeler describes a new genus of insect living commensally with certain ants. The general reader will, however, be specially interested in the so-called "mushroom gardens" formed by the ants in question. It appears that they cut and transport into their subterranean cellars large pieces of leaves, which are there divided into smaller fragments, and ultimately reduced to a fine pulp. "This pulp is heaped up, and soon becomes invaded by the mycelium of a fungus. The mycelium is kept aseptically clean—*i.e.* free from all species of fungi and even from bacteria—and induced to grow in an abnormal way by bringing forth minute swellings which constitute the only food of the ant colony. Möller likens these swellings to the 'kohlrabi' of the German kitchen gardens."

THE U.S. Department of Agriculture has published a *Bulletin*, by Dr. L. O. Howard, describing the principal insects affecting the tobacco plant. Although indigenous to America, this plant does not suffer so severely from insect attacks as do many other crops in the United States. It has no insect enemies peculiar to itself, although every year a certain amount of damage is done to the crop, which in some seasons may assume serious proportions. Remedial agencies in the form of poisons can be easily applied to the seed-beds, while arsenical spray may be employed at a later stage. Much good can also be effected by means of various solanaceous plants, such as nightshade, horse-nettle, and Datura, growing in the neighbourhood of the crop. Small clumps of these can be left growing, which will attract the noxious insects while the tobacco is still young, such clumps being subsequently cut down and destroyed with the pests upon them.

THE Trustees of the Indian Museum have issued a "Guide to the Zoological Collections exhibited in the Bird Gallery," by Mr. F. Finn. The author is so well known as an authority on Indian birds that any contribution from his pen on the subject cannot fail to be of value. But he has departed from the usual practice of ornithologists by relegating the groups generally termed "orders" to the rank of "suborders," thereby rendering avian classification much more in harmony with that of other vertebrate classes. He also refrains from adding the superfluous affix "*formes*" to such subordinal groups. While in every respect admirably suited to the special purpose for which it is intended, this "Guide" has, therefore, a value considerably exceeding that attaching to the majority of publications of a similar nature.

WE have received Parts vii. and viii. of "Papers from the Harriman Alaska Expedition," now in course of publication in the *Proceedings* of the Washington Academy of Sciences. Both are from the pen of Mr. T. Kincaid, and deal with entomology. Although the collection of insects and arachnids is very large indeed, it indicates that, with the possible exception of the beetles, which were previously collected during the Russian occupation, scarcely a beginning has been made towards bringing to light the arthropod fauna of this vast region. Mr. Kincaid commences with an account of the insects known as Tenthredinoidea, of which he describes a number of new forms. His second communication deals with the metamorphoses of certain beetles.

IN an article on Lepidoptera in South Devonshire, which appears in the December issue of the *Entomologist*, Mr. J. Jäger states that he never saw the clouded yellow butterfly in such profusion as in the week following August 15. They were simply swarming in the clover fields and lanes, and were probably as numerous as in 1877. Two plates of hybrid moths illustrate the continuation of the account of experiments on cross-breeding by Prof. Max Standfuss in the same issue.

AMONG other papers, the November issue of the *Journal* of the Quekett Microscopical Club contains one by Mr. A. A. Merlin, on "Structural Division of the Endoderm in Bacilli of the Bubonic Plague," which ought to prove of considerable interest to students of that disease at the present time.

THE December number of the *Entomologist's Monthly Magazine* contains a communication from Baron C. R. v. d. Osten Sacken, in which it is pointed out that the proper title of the malaria-producing mosquito is *Anopheles maculipennis*, and not, as has been generally supposed, *A. claviger*.

THE distinctive peculiarities of the skull of the puma forms the subject of a note by Dr. A. Dugés in the last issue of the *Memorias y Revista* de la Sociedad Cientifica "Antonio Alzate."

THE Anthropological Society of Paris has just published an authors' and subject index of all publications issued by it since its foundation in 1860.

MESSRS. A. GALLENKAMP AND CO. have issued a bulky and comprehensive catalogue of chemical apparatus, balances and accessories of various kinds used in the teaching of chemistry and related subjects and in practical analysis. The catalogue is one which may with advantage be kept for reference by science demonstrators and teachers.

THE third edition, revised and enlarged, of "An Elementary Treatise on Dynamics, containing Applications to Thermodynamics," by Dr. B. Williamson, F.R.S., and Dr. F. A. Tarleton, has been published by Messrs. Longmans, Green and Co. The whole work has been revised and some portions of the subject have been developed, more especially that on generalised co-ordinates in connection with Lagrange's and Hamilton's methods. Students intending to devote serious attention to the study of dynamics will find the volume a helpful introduction to the great treatises of Thomson and Tait and of Routh.

AN elaborate "Report on the Census of Cuba," by Lieut.-Colonel J. P. Sanger (Director) and Messrs. H. Gannett and W. F. Willcox (Statistical Experts), has just been published by the U.S. War Department. The census was the first step taken towards the establishment of an effective system of self-government in the island, and as no census had previously been taken by the people the difficulties were numerous and great. To induce the Cubans to take a real interest in the census, it was decided that the work should be performed by them, under the supervision of an officer of the United States Census, and this was actually done, so that when the enumeration was completed it was a census of Cubans by Cubans. The total population of Cuba, including the Isle of Pines and the neighbouring islets, was 1,572,797 on October 16, 1899. At a census taken under Spanish authority in 1887, the population was returned as 1,631,687, and if this is assumed to be correct, the diminution during the twelve intervening years is about 3·6 per cent. The native whites constitute 57·8 per cent., or considerably more than one-half of the population of Cuba; the foreign white people constitute 9 per cent.; the coloured people 32 per cent., or about one-third; and the remainder are Chinese. Illustrations of typical Cuban people and buildings, and numerous maps are included in the report.

READERS of popular periodicals know that articles upon scientific topics appear in every number of *Pearson's Magazine*. The December number contains several contributions of this character. The Rev. H. N. Hutchinson describes some prehistoric animals and illustrates them with some good pictures. Special mention is made of the giant ground sloth of Patagonia, for a living representative of which Mr. H. Prichard is seeking, having been sent to Patagonia for this purpose by the *Daily Express*. A number of striking coloured portraits of American Indians, showing the devices painted upon their faces, as marks

of distinction, accompany an article by Mr. T. Dreiser. The marble quarries at Monte Sagro, in the vicinity of Carrara, are described and illustrated by Mr. E. St. John Hart. Two series of photographs of a cat and dog jumping over an obstacle are contributed by Mr. A. C. Banfield. Dr. See's views upon the mode of formation of stellar systems are expounded in another article. Mr. George Griffith describes the line where the day changes, near the 180th degree of longitude, making it the text of an article upon the places where the twentieth century will commence; and Mr. Walter Wellman describes some of his Arctic experiences. Six pretty photographs of birds are reproduced in the *English Illustrated Magazine*.

THE use of gas thermometers at high temperatures is the subject of an interesting paper by Messrs. Holborn and Day (*Wied. Ann.* 68, 817). Experiments with porcelain vessels, glazed and unglazed, have shown that this material is unsuitable for the construction of the containing vessel, especially when the gas used is hydrogen. Platinum iridium vessels (10 or 20 per cent. Ir) containing nitrogen appear to be very trustworthy; after the thermometer has been heated to 1100° C. for a considerable time, the indications of the instrument at low temperatures remain unaltered. The thermo-elements usually employed for the measurement of high temperatures have been carefully compared with this gas thermometer, and the electromotive force represented as a quadratic function of the temperature. With these thermo-elements the melting-points of a series of metals have been determined, so that the calibration and control of other elements is made independent of the standard nitrogen thermometer. The au thors claim that the error in the determination of high temperatures (up to 1150° C.) does not exceed 1° C. The influence of air on the melting-points of copper and silver is interesting, as is evident from the following numbers—copper (pure) 1084·1° C., (in air) 1064·9° C.; silver (pure) 961·5° C., (in air) 955° C.

WE learn from the Marine Biological Laboratory at Plymouth that a male specimen of *Squilla desmarestii*, 2¾ inches long, was brought in last week by a shrimper who had been trawling inside Plymouth Breakwater. The rarity of this Stomatopod in Devonshire waters is shown by the fact that this is only the second specimen that has been taken at Plymouth since the laboratory opened in 1888, the other, a small one ¼-inch long, having been taken in the tow-net about three years ago.

THE additions to the Zoological Society's Gardens during the past week include two Puff Adders (*Bitis arietans*), a Yellow Cobra (*Naia flava*), two Delalande's Lizards (*Nucras delalandii*), thirty-two Spotted Slow Skinks (*Acontias meleagris*), three Rough-keeled Snakes (*Dasypeltis scabra*) three Smooth-bellied Snakes (*Homalosoma lutrix*), three Crossed Snakes (*Psammophis crucifer*), five Rhomb-marked Snakes (*Trimerorhinus rhombeatus*), two Coppery Snakes (*Prosymna sundevallii*), a Lineated Snake (*Boodon lineatus*) from South Africa, presented by Mr. J. E. Matcham; six Yellow-legged Frogs (*Rappia horstockii*) from South Africa, presented by Mr. W. L. Sclater; a Black Rat (*Mus rattus*), British, presented by Mr. E. Wormold; two Bactrian Camels (*Camelus bactrianus*, ♂ ♀) from Siberia, a Moose (*Alces machlis*, ♂) from North America, two Ashy-black Macaques (*Macacus ocreatus*) from the East Indies, a Golden-headed Marmoset (*Midas chrysomelas*) from South-east Brazil, a Red-footed Lemur (*Lemur rufipes*) from Madagascar, a Rufous-necked Wallaby (*Macropus ruficollis*) from New South Wales, four Westerman's Eclectus (*Eclectus westermani*) from Moluccas, a Plain-coloured Amazon (*Chrysotis inornata*) from South America, a Mongolian Pheasant (*Phasianus mongolicus*, ♂) from Mongolia, a Blackbird (*Turdus merula*, pied. var.), European, deposited.

OUR ASTRONOMICAL COLUMN.

LOCAL CONDITIONS FOR OBSERVATION OF THE TOTAL SOLAR ECLIPSE, 1901, MAY 17–18.—A pamphlet has been received containing information for observing parties and summaries of the climatological conditions along the track of the moon's shadow during the total solar eclipse in May 1901. The work is the report of a committee of the society, Koninklijke Natuurkundige Vereeniging in Nederlandsch-Indië, appointed at the request of the Government at Batavia.

With the exception of Batavia, which is out of the eclipse track, there is no regular meteorological service in the Malay Archipelago. Regular observations of rainfall, however, have been made during the period 1879–1900 at about 220 different places. As this factor alone does not give sufficient evidence as to the suitability of a place for observation of a total solar eclipse at noon, special series of climatic data have been obtained during the months of April, May and June 1900, in several places well situated for the purpose.

Twenty-two stations have been selected, extending from Padang, on the west coast of Sumatra, to Amboyna and Saparua, at the eastern extremity of the Celebes group. Tables are given showing the cloudiness of the sky, mean rainfall, daily and hourly rainfall.

As regards general condition of sky during May, the west coast of Sumatra appears to have the worst reputation, the percentage clearness being only 28 per cent., as against 50 per cent. for the Macasar Sea between Borneo and Celebes.

As regards rainfall, the western stations are apparently the better, Padang averaging fifteen rainy days in May, while at Amboyna there are twenty-seven. The actual rainfall is little or no indication of weather condition, as excessive rains do not involve a period of clouded sky; on the contrary, the atmosphere is cleared from dust by heavy rains, so that in the rainy season the sky is much more transparent than during the dry season. Several suggestions with respect to the accommodation at the various localities may be useful to observers.

The most convenient stations will probably be on the west coast of Sumatra. *Padang* is the residence of the Governor. is in weekly communication with Europe, has a telegraph office and four hotels.

Painan is situated south of Padang on the sea shore; it has no harbour, but is easily reached by land from Trusan Bay, where there is good anchorage.

Solok, in the interior, at an elevation of 1300 feet above sea-level, has a telegraph office and small hotel, and is connected with Padang by rail.

Pulo Lalang, an islet of the Lingga group, lies close to the central line, and possesses good anchorage for small vessels, which could be hired at Singapore.

Pontianak, on the west coast of Borneo, is in direct communication with Singapore once or twice weekly. It has a small hotel. The soil is said to be very swampy and unsuitable for large instruments.

Macasar, the capital of Celebes, has a telegraph office and two hotels, and is in direct communication with Singapore once a week.

Amboyna and *Saparua* are only in communication once or twice a month unless with special service.

As soon as a station is selected, arrangements should be made for securing the support of the civil officials, application being made in the first instance to the Governors or Residents. For temporary establishments bamboo and other materials are obtainable on the spot, and are inexpensive. Skilful craftsmen are not available except in the principal places. Portland cement may be purchased at Padang, Batavia, Surabaya and Macasar. No Customs duties are levied on instruments in the Dutch Colonies.

"ANNUAIRE ASTRONOMIQUE, &C., FOR 1901."—This well-known little annual volume, which is compiled by M. Camille Flammarion, will be found as useful as ever for the coming year. One finds in it all the more important details and events of celestial phenomena. Thus, we are given the facts about the coming solar and lunar eclipses, the chief tables of the solar system, charts of the sky for each month, showing the paths and positions of the planets. Further, there are several short notices on such subjects as solar spots, atmospheric observations, the eclipse of 1900, meteor observations, terrestrial magnetism, meteorological tables, &c. As a handy *vade mecum* for those who possess and use small equatorials, this annual should be specially very welcome.

"THE HEAVENS AT A GLANCE," 1901.—This handy little publication (now in its fifth year of issue) is practically a card calendar devoted to astronomical particulars, and is designed to serve as a handy remembrancer as to the phenomena predicted for any period, any further details required being obtained from a more bulky volume of reference. Besides the daily phenomena of importance, monthly summaries of the aspects of constellations, sun's declination, moon's phases, and positions of planets are given. This occupies about half of the sheet. The remainder is devoted to a series of useful descriptive notes and statistics of various celestial objects, including special features on the moon's terminator during the lunation, elongations and oppositions of the planets, data for eclipses, meteor shower radiants, and the coordinates of a selection of the brightest stars. This card should be especially useful to amateurs who find the larger reference books too cumbersome. It may be obtained from the compiler, Mr. Arthur Mee, F.R.A.S., Tremynfa, Llanishen, near Cardiff.

"COMPANION TO THE OBSERVATORY" FOR 1901.—This useful contribution to the astronomer's library has recently been issued, and will doubtless be accorded its usual welcome. The contents, occupying 36 pages, have from experience been so condensed as to leave out no information likely to be wanted by the general worker that little or no alteration has been made in the arrangement. Beginning with particulars of the sun's times of rising, setting, its declination, mean and sidereal time, and phases of the moon for every week, there follows a calendar showing the times of rising, southing and setting of the moon, and the longitude of the terminator for each day of the year; a list of the principal radiant points of meteors, compiled by Mr. Denning; ephemerides for all the planets, including the minor planets Ceres, Pallas and Vesta; and times of elongation, stationary points, &c.; solar and lunar eclipses, occultations; phenomena of the satellites of Mars, Jupiter, Saturn, Uranus and Neptune; ephemeris containing data for physical observations of the sun; mean places of variable stars, with epochs of maxima and minima; particulars of 115 double stars.

ARGON AND ITS COMPANIONS.[1]

THE discovery of krypton and neon was announced to the Royal Society in the early summer of 1898; and subsequently atmospheric air was found to contain a heavier gas to which the name of xenon was applied. Mr. Baly, in the autumn of the same year, called attention to the presence of helium lines in the spectrum of neon, an observation which confirms that made by Prof. Kayser, of Bonn, and by Dr. Friedländer, of Berlin.

At the same time we imagined that we had obtained a gas with a spectrum differing from that of argon and yet of approximately the same density; to this gas we gave the name metargon. It has now been found that the presence of the so-called metargon is to be accounted for by the fact that in removing oxygen from the mixture of these gases, which was then in our hands, phosphorus containing carbon was employed; this mixture when burned in oxygen yields a spectrum to some extent identical with that furnished by carbon monoxide, but differing from it inasmuch as lines of cyanogen are also present. We have no doubt that the so-called metargon, the spectrum of which is visible only at high pressure, and only when impure phosphorus has been employed to remove oxygen, must be attributed to some carbon compound. In spite of numerous experiments we have not yet succeeded in producing any gas in quantity which yields this composite spectrum. It is only to be obtained by a mixture of carbon monoxide with cyanogen.

To obtain the heavier gases krypton and xenon, a large amount of air was allowed to evaporate quietly; the residue was freed from oxygen and nitrogen, and then consisted of a mixture of krypton, xenon and argon, the last forming by far the largest portion of the gas; this mixture was liquefied by causing it to flow into a bulb immersed in liquid air, and the bulk of the argon was removed as soon as the temperature rose, the krypton and the xenon being left behind. By many repetitions of this process we were finally successful in separating these three gases from each other. While krypton has a considerable vapour-pressure at the temperature of boiling air, the vapour-pressure of xenon is hardly appreciable, and this afforded a means of finally separating these two gases from one another; in the complete paper the operations necessary to separate them are fully described.

For neon the process of preparation was different. The air liquefier furnished a supply of liquid air; the gas escaping from the liquefier consisted largely of nitrogen; this mixture was liquefied in a bulb immersed in the liquid air which the machine was making. When the bulb had been filled with liquid nitrogen a current of air was blown through the liquid until some of the gas had evaporated. That gas was collected separately, and deprived of oxygen by passage over red-hot copper; it contained the main portion of the neon and the helium present in the air. The remainder of the nitrogen was added to the liquid air used for cooling the bulb in which the nitrogen was condensed. Having obtained a considerable quantity of this light nitrogen it was purified from that gas in the usual manner, and the argon containing helium and neon was liquefied. By fractional distillation it was possible to remove the greater portion of the helium and neon from this mixture of gases, leaving the argon behind. Many attempts were made to separate the helium from the neon. Among these was fractional solution in oxygen, followed by a systematic diffusion of the two gases; but it was not found possible to raise the density of the neon beyond the number 9·16, and its spectrum still showed helium lines. It was not until liquid hydrogen, made by an apparatus designed and built by one of us (M. W. T.), had been produced in quantity, that the separation was effected; the neon was liquefied or perhaps solidified at a temperature of boiling hydrogen, while the helium remained gaseous. A few fractionations serve to produce pure neon; we did not attempt to separate the helium in a pure state from this mixture.

That these are all monatomic gases was proved by determination of the ratio of their specific heats by Kundt's method; the physical properties which we have determined are the refractivities, the densities and the compressibilities at two temperatures, and of argon, krypton and xenon the vapour-pressures and the volumes of the liquids at their boiling points.

The results are as follows:—

	Helium.	Neon.	Argon.	Krypton.	Xenon.
Refractivities (Air = 1) ...	0·1238	0·2345	0·968	1·449	2·364
Densities of Gases (O = 16)	1·98	9·97	19·96	40·88	64
Boiling-points at 760 mm.	?	?	86·9° abs.	121·33° abs.	163·9° abs.
Critical temperatures ...	?	below 68° abs.	155·6° abs.	210·5° abs.	287·7° abs.
Critical pressures	?	?	40·2 metres	41·24 metres	43·5 metres
Vapour-pressure ratio ...	?	?	0·0350	0·0467	0·0675
Weight of 1 c.c. of liquid	?	?	1·212 grammes	2·155 grammes	3·52 grammes
Molecular volumes	?	?	32·92	37·84	36·40

The compressibilities of these gases also show interesting features. They were measured at two temperatures—11·2° and 237·3°; the value of P.V. for an ideal and perfect gas at 11·2° is 17,710 metre-cubic-centimetres, and at 237·3° to 31,800. This is, of course, on the assumption that the product remains constant whatever be the variation in pressure. Now with hydrogen at 11·2° C. the product increases with the rise of pressure; with nitrogen, according to Amagat, it first decreases slightly and then increases slightly. With helium the increase is more rapid than with hydrogen; with argon there is first a considerable decrease followed at very high pressures by a gentle increase, although the product does not reach the theoretical value at 100 atmospheres pressure; with krypton the change with rise of pressure is a still more marked decrease, and with xenon the decrease is very sudden. At the higher

[1] A paper by Prof. William Ramsay, F.R.S., and Dr. Morris W. Travers. Read at the Royal Society on November 15.

temperature the results are more difficult to interpret; while nitrogen maintains its nearly constant value for P.V., helium decreases rapidly, then increases, and the same peculiarity is to be remarked with the other gases, although they do not give the product of P.V. coinciding with that calculable by assuming that the increase of P.V. is proportional to the rise of absolute temperature.

These last experiments must be taken as merely preliminary; but they show that further research in this direction would be productive of interesting results.

The spectra of these gases have been accurately measured by Mr. E. C. C. Baly, with a Rowland's grating; the results of his measurements will shortly be published. It may be remarked, however, that the colour of a neon-tube is extremely brilliant and of an orange-pink hue; it resembles nothing so much as a flame; and it is characterised by a multitude of intense orange and yellow lines; that of krypton is pale violet; and that of xenon is sky-blue. The paper contains plates showing the most brilliant lines of the visible spectrum.

That the gases form a series in the periodic table, between that of fluorine and that of sodium, is proved by three lines of argument:—

(1) The ratio between their specific heats at constant pressure and constant volume is 1·66.

(2) If the densities be regarded as identical with the atomic weights, as in the case with diatomic gases such as hydrogen, oxygen and nitrogen, there is no place for these elements in the periodic table. The group of elements which includes them is:—

Hydrogen.	Helium.	Lithium.	Beryllium.
1	4	7	9
Fluorine.	Neon.	Sodium.	Magnesium.
18	20	23	24
Chlorine.	Argon.	Potassium.	Calcium.
35·5	40	39	40
Bromine.	Krypton.	Rubidium.	Strontium.
80	82	85	87
Iodine.	Xenon.	Cæsium.	Barium.
127	128	133	137

(For arguments in favour of placing hydrogen at the head of the fluorine group of elements, see Orme Masson, *Chem. News*, vol. lxxiii., 1896, p. 283).

(3) These elements exhibit gradations in properties such as refractive index, atomic volume, melting-point and boiling-point, which find a fitting place on diagrams showing such periodic relations. Some of these diagrams are reproduced in the original paper. Thus the refractive equivalents are found at the lower apices of the descending curves; the atomic volumes, on the ascending branches, in appropriate positions; and the melting- and boiling-points, like the refractivities, occupy positions at the lower apices.

Although, however, such regularity is to be noticed, similar to that which is found with other elements, we had entertained hopes that the simple nature of the molecules of the inactive gases might have thrown light on the puzzling incongruities of the periodic table. That hope has been disappointed. We have not been able to predict accurately any one of the properties of one of these gases from a knowledge of those of the others; an approximate guess is all that can be made. The conundrum of the periodic table has yet to be solved.

ACTION OF TERRESTRIAL MAGNETISM ON THE RATES OF CHRONOMETERS.

IN the issue of the *Comptes rendus* of the Paris Academy of Sciences for November 26, vol. cxxxi., pp. 859-865, there is an important communication by Prof. A. Cornu, dealing with an experimental investigation of the action of a terrestrial magnetic field on the rate of a magnetised chronometer.

The observations have been carried out on a pocket half-chronometer, provided with anchor-escapement, compensated balance and palladium spiral, whose rate had previously been very satisfactory, but which had inadvertently become magnetised by a large electro-magnet. The generally prevalent idea is that a magnetised watch is quite untrustworthy until it has been completely demagnetised, but the author's research has convinced him that there is evidence of a regular law in the rate of such an affected timepiece, and therefore it should be possible to neutralise the disturbance, either by tables of correction formulæ, or by suitably disposed compensators.

The magnetisable parts are the pivots, anchor, spring, balance-wheel and accessories to the escapement. In watches of precision all direct contacts between steel parts are avoided by the use of hard stone bearings, so that the mutual actions are inductive effects. If, then, the watch be laid on a horizontal table at a definite orientation, the only disturbing external force capable of affecting its rate will be the terrestrial magnetic field. To test this, provision was made for varying the orientation of the balance by making the horizontal support movable about a vertical axis, and then keeping the watch or clock for several days successively in the four positions corresponding to the hours XII, III, VI, IX, pointing respectively to the Magnetic North.

Systematic observations from 1898 June 20 to 1900 November 17, furnish a series of values for the variations in rate at the four orientations, and the discussion of them has enabled Prof. Cornu to show that they may be represented by a *sinusoid*. The magnetic state of the watch remains sensibly constant; the semi-amplitude of the variations with the orientation was 10·37 secs., and the mean azimuth of the ascending node of the sinusoid about 260° 21′. This result is especially interesting and important in that this sinusoidal law is identical with that obtaining when a watch having a balance wheel slightly out of equilibrium is hung with its dial vertical and oriented to different azimuths. That is, gravity also produces, if the mean amplitude remains constant, a couple proportional to the vertical projection of the eccentricity of the centre of gravity. Here a series of observations of the rate of the same watch before it was magnetised are given, taken during the period 1890 October 26–1891 January 25, showing the fulfilment of the sinusoid law in this respect.

It would thus appear that the condition discovered by Phillips (*Annales des Mines*, 6th series, vol. ix., p. 321, 1866) for eliminating the disturbance due to gravitation may also be applied to the compensation for magnetisation.

As a crucial test of the truth of his deductions, Prof. Cornu performed a substitution experiment in which the earth's magnetism was directly allowed for. In a piece of cork of exactly the same form as the watch a cylindrical hole was cut in the position corresponding to the balance wheel. In this was supported a small compass needle, and the whole supported on a horizontal table. By means of a jointed arm a bar magnet was held in such a position that the earth's magnetism was neutralised, leaving the needle astatic. This done, the watch was substituted for the cork, the orientation of the balance wheel being the same as the small compass in the cork. This substitution of cork model, getting astatic position by bar magnet, and replacement of watch, was repeated for the four orientations, and the daily rate carefully determined. It was found to be sensibly *constant in all positions*.

The paper concludes with the following summary:—

(1) Chronometers of precision are influenced by variations of the magnetic field in which they are placed to an amount depending on the degree of magnetisation of the balance wheel and spring.

(2) It is important to determine the magnetic moment of the balance wheel, mounted or not on the spiral.

(3) In observatories studying chronometer rates it is necessary to regularly determine the comparative variations in four rectangular azimuths for calculating the formulæ of correction.

(4) In all cases it should be the endeavour to attain an amplitude of 440° for the oscillations of the balance wheel, as recommended by Phillips, to eliminate the action of the terrestrial magnetic couples.

(5) For precaution, in observatories as well as on board ship, it would be well to envelop each chronometer with a thick box of iron, so that the relative action of the terrestrial field may be lessened.

C. P. B.

THE EFFECTS OF AN EARTHQUAKE ON HUMAN BEINGS.

CAPTAIN DUTTON'S valuable memoir on the Charleston earthquake of 1886 contains many accounts of the effects of this great earthquake on human beings. Nowhere could they be more vivid than in Charleston itself. "On every side," says one witness, "were hurrying forms of men and women, bare-headed, partially dressed, some almost nude [the earthquake

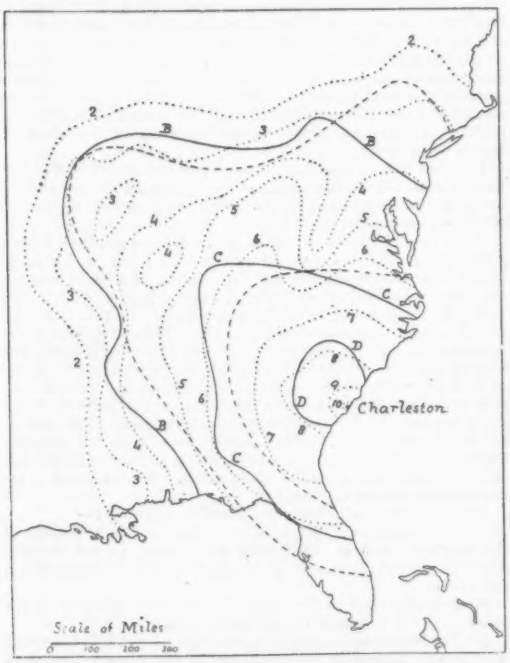
occurred at 9.51 p.m.], and all nearly crazed with fear and excitement. . . . A few steps away, under the gas-lamp, a woman lies prone and motionless on the pavement, with upturned face and outstretched limbs, and the crowd which has now gathered in the street passes her by, none pausing to see whether she is alive or dead . . . ; many voices are speaking at once, but few heed what is said." Between this, which must surely be almost the limit of wild fear in a crowd, and the merely interested curiosity of the most distant observers, there seems to be nearly every stage of mental effect recorded. Such terms as "greatest consternation," "fright and excitement unparalleled," and "terror amounting to wild frenzy," are, of course, too dependent on the narrator and too vague to be of any value as degrees in a scale of mental effects; but the resulting actions are less liable to error or exaggeration, and these may be roughly classified as follows, the different degrees being lettered to avoid confusion with the numbers of the soseismal lines:

(A) No persons leave their rooms.

(B) Some persons leave their houses.

(C) Most persons run into the streets, which are full of excited people.

(D) People rush wildly for open spaces, and remain all night out of doors.



In the third degree of the scale, I included at first the hasty dispersal of meetings; but, when the places at which this occurred are plotted on a map, it is evident that this effect would find an appropriate place under the second heading. A crowd in one room is more liable to excitement and fear than are persons in separate houses.

In the accompanying map, the dotted curves are the isoseismal lines as drawn by Captain Dutton. The continuous curves bound the areas in which the effects corresponding to the three higher degrees of the scale were observed. The curve for the first degree of course coincides with the outermost isoseismal line.

It will be seen that there is a certain rough agreement between these curves and the isoseismal lines. The curve D and the isoseismal 8 are not far apart; in other words, if the shock was strong enough to throw down chimneys or make cracks in the walls of buildings, then people thought it wiser to camp out for the night. The curve C and the isoseismal 6 coincide approximately; that is, people rushed precipitately into the streets if the movement made chandeliers, pictures, &c., swing. On the whole, the curve B roughly follows the isoseismal 3; so that, if the shock was not even strong enough to cause doors and windows to rattle, some persons were so alarmed that they left their houses, and public meetings were dispersed. Whether these effects were due to the rarity of the phenomenon or to the highly-strung nerves of the American people, it may, I think, be inferred that in no other civilised country would such alarm be shown at a sudden and unexpected occurrence.

Captain Dutton also gives many records of a feeling of nausea at the time of the earthquake; and, however excitable the observers may have been, these accounts are probably trustworthy, for this is not at all generally known to be a result of earthquake-motion. I have marked these places on a map, and it is curious that, with one or two exceptions, they all lie between the two broken lines of the figure. The most distant places at which the feeling was noticed are Blue Mountain Creek (New York), 823 miles, and Dubuque (Iowa), 886 miles, from Charleston. The outer boundary of the nausea area follows roughly the curve B, but is generally inside it; the inner boundary is so close to the curve C as to suggest that there may be some connection between them, that, in the wild hurry to reach the street, the slight feeling of nausea might escape notice.

CHARLES DAVISON.

THE CAMBRIDGE SENTINEL MILK STERILISER.

THIS is a simple and automatic milk steriliser for domestic use. It is made in three forms; in one, which is intended for use on an ordinary fire, a tube which carries an alarm bell at the top is inserted through the lid of the saucepan. When the desired temperature (85° C.) is reached, a trigger contained in the tube is automatically released, and the bell rings, thus warning the attendant to take the pan off the fire. In a second form the action is automatic. A saucepan containing the sensitive trigger is placed on a gas stove, and when the proper temperature is reached the release of the trigger causes the supply of gas to be automatically cut off. A third form is arranged for use with a spirit lamp. In each case, the automatic mechanism is actuated through the melting of an easily fusible alloy.

For the apparatus it is claimed (1) that it is simple and works automatically, (2) that the temperature (85° C.) attained does not impair the flavour or the nutritive qualities of the milk, (3) that injurious micro-organisms, including tubercle, are destroyed. Dealing with these claims in order, the apparatus certainly acts automatically and seems to be of simple construction. With regard to the first or bell form, however, the sound of the bell is so slightly audible that it would certainly be missed unless the attendant were listening for it, and in all probability in nine cases out of ten the milk would be boiled. The second form, with gas stove and automatic cut-off, works quite well and is much to be preferred. With regard to the temperature at which the signal is given or the cut-off takes place there is some difference, according to the amount of fluid which is being treated. Dealing with the two-pint size we have observed the following temperatures:

		Bell Form.	Cut-off Form.
Water	Half pint	94° and 95° C.	95° and 93° C.
	One pint	87·5° ,, 89°	86° ,, 87°
	Two pints	87° ,, 86°	84° ,, 85°
Milk	Half pint	98° (frothing)	95°
	Two pints	87°	84°

It will thus be seen that there is a considerable variation in the temperatures.

As to the second point, we consider that the temperature of 85° C. is too high, and we believe that the experiments of Duclaux and others have conclusively shown that milk cannot be heated above 70° C. without altering its flavour and nutritive qualities. Tested practically, milk heated in the apparatus and immediately cooled has a pronounced flavour, little less marked than milk which has been just boiled and then cooled. Three samples—(1) untreated, (2) sterilised in the apparatus and immediately cooled, (3) boiled and cooled—were submitted to three individuals, who separately tasted them; two of the individuals were unable to distinguish between the sterilised and boiled samples; the third said "that the sterilised sample seemed a little less boiled than the other." The flavour being so markedly altered, we doubt whether the claim that the nutritive qualities of the milk are unchanged can be substantiated.

The temperature 85° C. was probably chosen because it may be relied upon with certainty to kill pathogenic organisms, especially the tubercle bacillus. We believe, however, that a temperature of 65° C., acting for twenty minutes, is sufficient to kill the tubercle bacillus, and that, therefore, pasteurised milk, *i.e.*, milk heated to 68° C. for twenty minutes, is quite safe, and certainly its flavour is almost unaltered. We are aware, of course, that some observers claim that tuberculous milk may retain its infective properties after pasteurisation, but the work of Theobald Smith seems to explain the contradictory results which have been obtained. He found that tubercle bacilli suspended in water, saline solution, bouillon or milk were destroyed at 60° C. in 15—20 minntes. If, however, a pellicle forms on the milk, then the tubercle bacilli in the pellicle seem to be protected, and may survive an hour's heating at 60° C. (*Journ. Exper. Med.*, iv, 2, p. 217).

NEW SYNTHESES OF SOME DIUREIDES.

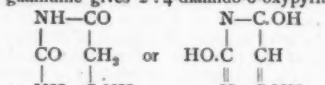
W. TRAUBE publishes in the present number of the *Berichte* further details on the new syntheses of uric acid, xanthine and the methyl derivatives of the latter—theobromine, theophylline and caffeine. The starting point is either cyanacetic acid or its ester. Cyanacetic acid and urea in presence of phosphorus oxychloride form cyanacetyl urea,

$$NH_2.CO.NH.CO.CH_2CN.$$

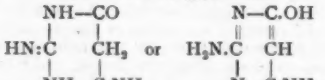
Also cyanacetic ester and guanidine combine with the separation of alcohol, forming cyanacetyl guanidine,

$$NH_2C(:NH).NH.CO.CH_2.CN.$$

The further treatment of these two compounds is similar. With alkalis they are converted into cyclic (pyrimidine) compounds. Cyanacetyl urea forms 4-amido-2 : 6-dioxypyrimidine, whilst cyanacetyl guanidine gives 2 : 4-diamido-6-oxypyrimidine

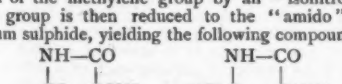


4-amido 2 : 6-dioxypyrimidine.

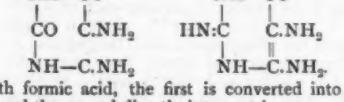


2 : 4-diamido-6-oxypyrimidine.

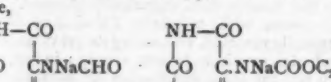
They are then treated with nitrous acid, which replaces the hydrogen of the methylene group by an "isonitroso" group, and this group is then reduced to the "amido" group by ammonium sulphide, yielding the following compounds :



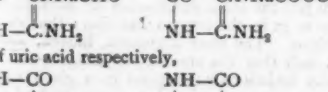
Boiled with formic acid, the first is converted into a formyl derivative and the second directly into guanine,



If chloroformic ester is used in place of formic acid, the first yields a urethane. Both formyl derivative and urethane form sodium salts, which, when heated, yield the sodium compound of xanthine,



and that of uric acid respectively,



Sodium xanthine. Sodium urate.

Guanine may be readily converted by Fischer and Strecker's method into xanthine, and by methylation into theobromine and caffeine, whereas by using methyl urea in the formation of cyanacetyl urea in the first method, or by methylating the formyl compound, theobromine, theophylline, caffeine and the corresponding uric acids may be produced. A patent has been taken out by the discoverer for these processes.

ARTIFICIAL RAIN.[1]

THE question perpetually arises in the popular mind as to whether man cannot produce rain or drought according as his needs may dictate. The possibility of doing this is never questioned by barbarians, who have their professional rain makers and great medicine men, and superstitiously attribute to them all power over nature. In some parts of the Christian world it has been believed that man could bring about rain or drought, not by his own power, but by intercession with the Creator, who would, perhaps, work a miracle on his behalf. During the past thousand years miracles have been confessedly rare, and some consider it almost impious for a man to dare to interfere with the operations of nature on a large scale; some even refuse to be doctored for disease.

The recognition of the truths revealed by modern science has made it evident that man can affect the weather only by understanding and making use of the laws of nature. He must do it in a natural or scientific way, not through any supernatural power or in any miraculous way. In fact, those who have a very imperfect knowledge of the laws of nature, if any at all, are often inclined to believe that there really must be some process known to science, or still to be discovered, by which man can bring abundant rain from the clouds when and where he needs it. They point to the popular belief that rain follows great battles, as proving that there is some way by which to affect the clouds—it may be through the noise of the battle, or it may be the burning of the gunpowder, or it may be a possible electric disturbance. They point to the reputed influence of lightning rods, which are supposed to draw the lightning from the skies and prevent the formation of hail.

In these and other matters there is abundant room for self-deception. It would be a great mistake to conclude that any battle by reason of its noise, or heat, or gunpowder has had any effect in the way of producing rain, or that the lightning rods have had any effect in producing or preventing hail. The statistics that are supposed to substantiate such conclusions do not really prove anything of the kind, and yet many are deceived by them because in reasoning upon the phenomena of nature they forget to apply the simplest laws of logic, and are carried away by emotions or preconceived opinions or the plausible suggestions of others. This is not at all singular, for the history of man's progress in knowledge is the history of a long series of mistakes covering thousands and tens of thousands of years. All have to learn by bitter experience, and if science seems to have made rapid progress during the past century, that should not blind our eyes to the fact that errors may still prevail among the professional men of science as well as the rest of mankind.

In the special matter of the artificial formation of rain we heartily endorse the statement that if it is in any way possible to bring this about we must labour to discover it; in fact, we eventually shall discover the way, if there be one, but thus far nothing has been accomplished to justify us in believing that feasible methods exist or are likely to exist. Various methods have had their advocates both in Europe and America, and the citizens of the United States, with a nervous energy that is greatly to be admired, have given a full and fair trial, at great expense, to several methods advocated by men of imperious natures that would brook no denial short of nature's own experimental demonstration of their errors. Thus the rain-making by explosives was most thoroughly tested by order of Congress at an expense to the public of many thousands of dollars, and the results have been discussed sufficiently, both in public and private, to show that nothing in the way of rain, and probably nothing in the way of cloud or mist, was produced. One of the first experimental trials was made quite near Washington, D. C., at night-time, November 2-3, 1892, when a series of clouds with showers were passing over the neighbouring country, and these continued right along for several hours

[1] Abridged from a contribution by Prof. Cleveland Abbe to the U.S. *Monthly Weather Review*.

quite independent of the bombardment. The reports from numerous observers showed that as the showers moved along over the earth's surface those in front of it reported that the noise of the exploding dynamite occurred just before the shower; those in the wake of the shower reported that the shower came before the explosion, while those in the midst of the shower, of course, heard the explosion while it was raining. There was no evidence that the explosion had any effect on the clouds. Careful observations in Washington, D.C., during the whole of this first experiment, and during subsequent experiments with explosives, warranted the conclusion that no rainfall was produced by bombardment.

About that time a "rain wizard" commenced operating in Ohio. His method consisted in locking himself in a barn, house, luggage van or other room, wherein he made a fire and burned or evaporated certain chemicals, the smoke of which rose through the roof out of some impromptu chimney or stove-pipe and dissipated itself in the thin air. Of course it was claimed that the chemicals exerted a great influence on the atmosphere and forced rain to come. Occasionally rain did come after one, two, or three days of a chemical performance, but equally often it did not come. The Weather Bureau was often importuned for advice as to when the wizard should be called to any given town, and whether the inhabitants would be justified in paying him his fee of several hundred dollars. Eventually, a prominent railway company rigged up a car for his use, and during the years 1892–4 made it convenient for all the citizens on its lines to invoke the aid of "the rain producer." Of course there were numerous cases in which the operations were followed by rain; those who studied the Daily Weather Map could see at a glance that these rains accorded with the general weather conditions and had nothing to do with the rain-making operations. So long as frequent rains occurred, although they were natural and were predicted by the Weather Bureau on the basis of the weather map from day to day, yet the farmers of Iowa, Kansas and Nebraska, ignoring this fact, were sure to accredit all success to the wizard.

During the last great drought in California, 1898–1899, the citizens of one city authorised an extensive and expensive system of experiments by gases and by cannon, but were fortunately saved the necessity of actually wasting their money by the fact that an abundant rain fell naturally just before they were ready to begin their own operations.

Occasionally we still receive newspaper items reviving the old story that floods of rain were broken up by cannonading at Rome, or that rain was produced by cannonading in Italy, or that hailstorms were averted from a special vineyard that was protected by lightning rods while neighbouring vineyards suffered. These are all repetitions of the same old myths, or repetitions of useless experiments, and the intelligent reader may dismiss them as having no foundation. No matter how severely his land may be suffering from drought or flood, he should seek some other mode of relief and not waste his time and money in efforts to change the nature of the clouds or the atmosphere.

ON THE STATISTICAL DYNAMICS OF GAS THEORY AS ILLUSTRATED BY METEOR SWARMS AND OPTICAL RAYS.[1]

IMAGINE a cloud of meteors pursuing an orbit in space under outside attraction—in fact, in any conservative field of force. Let us consider a group of the meteors around a given central one. As they keep together their velocities are nearly the same. When the central meteor has passed into another part of the orbit, the surrounding region containing these same meteors will have altered in shape; it will in fact usually have become much elongated. If we merely count large and small meteors alike, we can define the density of their distribution in space in the neighbourhood of this group; it will be inversely as the volume occupied by them. Now consider their deviations from a mean velocity, say that of the central meteor of the group; we can draw from an origin a vector representing the velocity of each meteor, and the ends of these vectors will mark out a region in the velocity diagram whose shape and volume will represent the character and range of deviation. It results from a very general proposition in dynamics that as the central meteor moves along its path the region occupied by the group of its neighbours multiplied by the corresponding region in their velocity diagram remains constant. Or we may say that the density at the group considered, estimated by mere numbers, not by size, varies during its motion proportionally to the extent of the region on the velocity diagram which corresponds to it.

This is true whether mutual attractions of the meteors are sensibly effective or not; in fact, the generalised form of this proposition, together with a set of similar ones relating to the various partial groups of coordinates and velocity components, forms an equivalent of the fundamental principle of Action which is the unique basis of dynamical theory.

Now, suppose that the mutual attractions are insensible, and that W is the potential of the conservative field: then for a single meteor of mass m and velocity v we have the energy $\frac{1}{2}mv^2+m$W conserved: hence if δv_1 be the range of velocity at any point in the initial position, and δv_2 that at the corresponding point in any subsequent position of the group, we have $v_1\delta v_1=v_2\delta v_2$, these positions remaining unvaried and the variation being due to different meteors passing through them. But if $\delta\omega_1$ and $\delta\omega_2$ are the initial and final conical angles of divergence of the velocity vectors, corresponding regions in the velocity diagram are of extents $\delta v_1.v_1^2\delta\omega_1$ and $\delta v_2.v_2^2\delta\omega_2$: these quantities are, therefore, in all cases proportional to the densities at the group in its two positions. In our present case of mutual attractions insensible, the volume density is thus proportional to $v\delta\omega$, because $v\delta v$ remains constant. Now the number of meteors that cross per unit time per unit area of a plane at right angles to the path of the central meteor is equal to this density multiplied by v: thus here it remains proportional to $v^2\delta\omega$, as the central meteor moves on. In the corpuscular formulation of geometrical optics this result carries the general law that the concentration in cross-section of a beam of light at different points of its path is proportional to the solid angular divergence of the rays multiplied by the square of the refractive index, which is also directly necessitated by thermodynamic principles; as a special case it limits the possible brightness of images in the well-known way.

In the moving stream of particles we have thus a quantity that is conserved in each group—namely, the ratio of the density at a group to the extent of the region or domain on the velocity diagram which corresponds to it; but this ratio may vary in any way from group to group along the stream, while there is no restriction on the velocities of the various groups. If two streams cross or interpenetrate each other, or interfere in other ways, all this will be upset owing to the collisions. Can we assign a statistical law of distribution of velocities that will remain permanent when streams, which can be thus arranged into nearly homogeneous groups, are crossing each other in all directions, so that we pass to a model of a gas? Maxwell showed that if the number of particles each of which has a total energy E is proportional to ϵ^{-hE}, where h is some constant (which defines the temperature), while the particles in each group range uniformly, except as regards this factor, with respect to distribution in position and velocity jointly, as above, then this will be the case. In fact, the chance of an encounter for particles of energies E and E′ will involve the product $\epsilon^{-hE}\epsilon^{-hE'}$ or $\epsilon^{-h(E+E')}$, and an encounter does not alter this total energy E + E′; while the domains or extents of range of two colliding groups each nearly homogeneous and estimated, as above, by deviation from a central particle in position and velocity jointly, will have the same product after the encounter as before by virtue of the Action principle. It follows that the statistical chances of encounter, which depend on this joint product, will be the same in the actual motion as are those of reversed encounter in the same motion statistically reversed. But if the motion of a swarm with velocities fortuitously directed can be thus statistically reversed, recovering its previous statistics, its molecular statistics must have become steady; in fact, we have in such a system just the same distribution of encountering groups in one direction as in the reverse direction: thus we have here one steady state. The same argument, indeed, shows that a distribution, such that the number per unit volume, of particles whose velocity deviations correspond to a given region in the velocity diagram, is proportional to the extent of that region without this factor ϵ^{-hE}, will also be a steady one. This is the case of equable distribution in each group as regards only the position and velocity diagrams conjointly; but in this case each value of the resultant velocity would occur with a frequency

[1] A paper read by Dr. J. Larmor, F.R.S., before Section A of the British Association at Bradford, September, 1900.

proportional to its square, and a factor such as e^{-hE} is required to keep down very high values. The generalisations by Boltzmann and Maxwell to internal degrees of freedom would lead us too far, the aim here proposed being merely concrete illustration of the very general but purely analytical argument that is fully set forth in the treatises of Watson, Burbury and Boltzmann.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—Mr. H. Herbert Smith has been appointed Gilbey lecturer in agriculture for the next three years. Prof. Macalister and Dr. Habershon have been appointed additional examiners for medical degrees.

The Walsingham Gold Medal in biology has been awarded to Mr. H. Dale of Trinity College, and the Bronze Medal to Mr. R. C. Punnett of Caius College.

The University of New Brunswick has been affiliated to the University of Cambridge.

The researches submitted to the Board for physics by Mr. J. B. B. Burke, Mr. W. C. Henderson and Mr. A. H. Peake, advanced students, have been approved as qualifying for the B.A. degree.

Dr. Anningson, Dr. Collingridge, Prof. Sims Woodhead and Dr. Tatham have been appointed examiners in sanitary science.

The proposal for enabling the examiners to award a first class to candidates for the Natural Sciences Tripos, Part II., who show a sufficient knowledge of two subjects, but do not quite attain the first class standard in either, has been rejected by the Senate.

THE Childhood Society offers prizes of two guineas and one guinea for the two best essays on some prescribed subjects referring to the mental and physical characteristics of children. Information can be obtained from the Hon. Secretary of the Society, 72 St. Margaret Street, London, W.

GLANCING through the Calendar of the University College at Nottingham, we notice the announcement that the Board of Education is prepared to pay three-fourths of the laboratory fees at the College of Government teachers engaged in science teaching who wish to become familiar with practical methods. This rule applies to other University Colleges.

SCIENTIFIC SERIALS.

American Journal of Science, November.—Elaboration of the fossil cycads in the Yale Museum, by L. F. Ward. The collection contains twenty-nine different species of cycads from the Black Hills, represented by nearly eight hundred specimens. A number of new species are described, and termed respectively Cycadeoidea superba, rhombica, heliochorea, utopiensis, reticulata, minima, and protea.—Chemical composition of turquoise, by S. L. Penfield. Turquoise is so uniform in its chemical constitution that it can hardly be considered an accidental mixture of an aluminium phosphate and a copper phosphate. Copper and iron must be regarded as constituents rather than impurities. The author derives it from ortho-phosphoric acid, in accordance with the formula

$$[Al(OH)_2,Fe(OH)_2,Cu(OH),H]_3PO_4.$$

—Quartz-muscovite rock from Belmont, Nevada, by J. E. Spurr. The rock described occurs in a large dyke just east of Belmont. It occurs in large masses, changing gradually and irregularly into alaskite or muscovite-biotite granite. It is identical with the "beresite" occurring in the Urals in association with veins of auriferous quartz.—Volumetric estimation of copper as the oxalate, with separation from cadmium, arsenic, tin and zinc, by C. A. Peters. The precipitation of copper oxalate from solutions containing at least 0·0128 grammes of the oxide and saturated with oxalic acid is practically complete. Moderate amounts of copper may be determined quantitatively as the oxalate by precipitation with oxalic acid and titration of the precipitate by potassium permanganate. Copper may also be separated from other metals in the presence of nitric acid by the addition of considerable amounts of oxalic acid.—Synopsis of the collections of invertebrate fossils made by the Princeton expedition to Southern Patagonia, by A. E. Ortmann. Thirty-six new species are described, mostly gastropoda.—The kathode stream and X-light, by W. Rollins. The author advances two arguments against the supposition that the kathode stream particles are always of the same size, move with the same speed, and carry the same charge. Mercury particles appear too heavy to generate X-rays, and the loss of material from kathodes of different metals is not the same.

Bollettino della Società Sismologica Italiana, vol. vi., 1900–1901, No. 4.—The great earthquake of June 12, 1897, by R. D. Oldham. A summary of the author's report on the great Indian earthquake, and of his memoir on the propagation of earthquake motion to great distances (*Phil. Trans.*, 1900A, pp. 135–174).—A new protographic seismic pendulum, by G. Costanzi. A description of an apparatus for recording only the first part of the earthquake-motion, the surface on which the record is made being withdrawn from the moving pendulum.—Principal eruptive phenomena in Sicily and the adjacent islands during the year 1899, by S. Arcidiacono.—Notices of earthquakes recorded in Italy (June 5 to August 4, 1899), by A. Cancani, the most important being the Tuscan earthquake of June 27, the Latian earthquake of July 19, and distant earthquakes on June 5, 14, 17, July 7, 11, 12 and 14.

SOCIETIES AND ACADEMIES.

LONDON.

Linnean Society, November 15.—Mr. C. B. Clarke, Vice-President, in the chair.—Mr. W. B. Hemsley, F.R.S., F.L.S., exhibited a number of specimens and drawings of Fitchia (Hook. f. in *Lond. Journ. Bot.* iv. p. 640, pls. 23, 24), including a new species from the island of Raratonga in the Cook Archipelago, discovered by Mr. T. F. Cheeseman. The genus was described from specimens thought to have been procured on Elizabeth Island, a remote coral island in the Eastern Pacific; but Mr. Hemsley gave reasons for believing that the locality of the plant described by Sir Joseph Hooker was Tubnai Island in the same latitude, but 20° further to the west: an island of volcanic origin and mountainous, and, therefore, more likely than a coral island to be the habitat of such a plant, especially as it was originally discovered by Banks and Solander in Tahiti. Only three or four species are known: they are small resiniferous shrubs of tree-like habit, with rather thick branches, opposite simple leaves borne on slender stalks, and terminal, usually solitary flower-heads. Mr. Hemsley next exhibited an abnormal cluster of fruits of the edible chestnut found by Mr. Charles Read of Sway in the New Forest, and forwarded to Kew by the Rev. J. E. Kelsall. Usually there are two or three, rarely four in a cluster; but in the specimen exhibited there were at least fifteen, the largest nuts measuring about an inch in their greatest diameter. He also exhibited a curious flask-shaped bird's nest, which had been sent to Kew by Mr. J. H. Hart, Director of the Botanic Garden, Trinidad, but without any information concerning the bird which built it. It was constructed almost entirely of the soft plumose seeds of a species of Tillandsia (Bromeliaceæ). It measured a foot in length and between four and five inches in its greatest diameter, and had the entrance at the base, the receptacle for the eggs being near the top of the inside. Mr. J. E. Harting, in reply to a question from the chairman, said that without seeing a specimen of the bird which had built the nest in question, it was not easy to name the species with certainty; but that it was doubtless the nest of an Icterus, and probably of *Icterus leucopteryx*, commonly known in the West Indies as the Banana-bird.—Mr. James Groves, on behalf of Mr. Cecil R. P. Andrews, exhibited specimens of a Sea Lavender new to the Channel Islands, *Statice lychnidifolia*, Girard, discovered by Mr. Andrews in August of the present year growing sparingly on low rocks by the sea in Alderney in company with *S. occidentalis*, the most nearly allied British species. Mr. Groves pointed out that the interest of the record consisted, not so much in the fact of the plant occurring in Alderney (being a native of the adjacent French coast, and the Channel Islands being geographically more French than British), as in the fact that a species should be added to the flora of one of our possessions so near home.—Mr. W. C. Worsdell read a paper entitled "Further Observations on the Cycadaceæ," intended to throw additional light on the problem as to the phylogenetic origin and relationships of this group of plants.—On behalf of Miss Alice L. Embleton a paper was read by Prof. G. B. Howes on

a new entozoic Copepod (*Goidelia echiura*) found together with an Infusorian (*Trichodina*) in the rectum of a new Japanese marine Worm (*Echiurus unicinctus*) recently described by her in the Society's *Transactions*. This Copepod is eyeless, and a description was given of its appendages in both the adult and metamorphic stages, from careful dissections under the microscope made in one of the laboratories of the Royal College of Science.

Geological Society, November 21.—J. J. H. Teall, F.R.S., President, in the chair.—A Monchiquite from Mount Girnar, Junagarh (Kathiawar), by Dr. J. W. Evans. After a brief account of the rocks of the monchiquite-type, in which ferromagnesian silicates are embedded in an isotropic matrix with the chemical constitution of analcime, the author describes an example from Mount Girnar, where it is associated with a nepheline-syenite intrusive in a mica-augite-diorite. The most striking feature of this rock is the occurrence of colourless spheres of various sizes up to about 1 mm. in diameter. The rest of the rock is mainly composed of a hornblende of the barkevikite-type; a pale green augite is also present.—The geology of Mynydd-y-Garn (Anglesey), by Charles A. Matley. Mynydd-y-Garn, a hill of less than 600 feet elevation, stands above the village of Llanfair-y'nghornwy in north-west Anglesey. The mass of the hill is an inlier of sericitic and chloritic phyllites (Garn Phyllites), surmounted by a massive conglomerate (Garn Conglomerate), and surrounded by black slates and shales of apparently Upper Llandeilo age. The general dip of all the rocks is northerly and north-easterly. The Garn Phyllites are usually green altered shales and fine gritty rocks, and are intensely contorted near their southern boundary. Even where not contorted they show under the microscope evidence of powerful earth-movement. They are considered by the author to be part of the "Green Series" of northern Anglesey. They are cut off to the west and south by a curved fault, probably a thrust, which brings them against Llandeilo slates and breccias. The district around Mynydd-y-Garn has been affected since Llandeilo times by two powerful earth-movements, acting one from the north, the other from the north-east. The first-mentioned prevailed in the area west and north-west of the hill, where the pre-Llandeilo rocks are frequently shattered to crush-conglomerates. Around Mynydd-y-Garn itself and east of it the principal direction of movement has been from the north-east; south of the hill the structure is, perhaps, the result of the interference of these two movements.—On some altered tufaceous rhyolitic rocks from Dufton Pike (Westmorland), by Frank Rutley, with analyses by Philip Holland. The specimens described were collected by the late Prof. Green and Mr. G. J. Goodchild from the Borrowdale volcanic series which constitutes the central mass of Dufton Pike, and the chief interest attaching to them is their alteration, probably as the result of solfataric action.

Anthropological Institute, November 22.—Mr. W. Gowland, Vice-President, in the chair.—A paper was read by Messrs. MacIver and Wilkin on their Algerian journey. The main object of the journey was to investigate the evidence for the Libyan origin of Prof. Flinders Petrie's "New Race." The districts especially investigated were the Aurès mountains, inhabited by the Chawia, and Kabylia; and a large number of lantern slides were secured which were exhibited in illustration of the paper. The manufacture of pottery was described in detail; the readers considered that the identity of one entire class of Kabyle ware with that of prehistoric Egypt in respect of colour, technique, and details of ornament, as well as numerous coincidences of form, proved the close culture connection of the ancestors of the Berbers with prehistoric Egypt. Other classes of pottery seemed to have been directly derived from or communicated to Cyprus. Turning to questions of anthropography, the readers showed that the Berbers are essentially a white race with brown-black hair, brown or hazel eyes and a skin which is really red-white. They are, therefore, the true representatives of the white Libyans of the Egyptian wall-paintings. Blondes occur but seldom; they form not more than 10 per cent. The paper concluded with a summary of the results of an anthropometrical examination of a very large series of prehistoric Egyptian and modern Berber skulls; the results showed the two races to be quite distinct. The expedition has strengthened the case for culture connection between Libya and Egypt, but disproved the theory of common race.

November 27.—Mr. C. A. Read, President, in the chair.—Prof. E. B. Tylor communicated, and commented on, a paper by Mr. Paxton Moir on stone implements in Tasmania. The paper described the sites on which the stones were found and the uses to which the various forms were put. The types included knives and hand axes which were fairly common, and also a certain number of concave "scrapers" and pointed "groovers." There was, however, considerable difference of opinion as to the propriety of using a very definite terminology and attributing to the manufacturers very definite intentions where there was obviously very little command over the materials. Another point which roused some discussion was whether the stones were shaped to fit the hand or selected because they were so shaped, or whether the adaptability of the hand did not account for the readiness with which a "grip" was found.—A large number of Tasmanian implements being on the table, the points raised in the discussion received practical illustrations. There were also exhibited, on behalf of Mr. Alfred Sharpe, C.B., H.B.M. Commissioner of Nyassaland, a double clapperless bell, a stone implement of uncertain use, and a wooden stool supported on a carved female figure with prominent keloid scars, and native head-dress, from Angoniland.

Royal Microscopical Society, November 21.—Mr. Wm. Carruthers, F.R.S., President, in the chair.—Mr. Nelson exhibited and described an erect image dissecting microscope by Leitz, and sent for exhibition by Mr. C. Baker. The erection of the microscopic image, effected by means of Porro prisms, was first described by Ahrens in the *Journal* of the Society in 1888. The instrument was valuable as a dissecting microscope; it was provided with handrests and three objectives, having a very long working distance.—Mr. Disney exhibited a diffraction plate having the lines ruled in concentric circles, by which the diffraction bands were separated with great clearness. The rulings were about 7000 to the inch. He also exhibited a steel brooch the surface of which had been ruled in the same way.—Mr. C. F. Rousselet exhibited an electric lamp for use with the microscope.—The president called attention to the exhibition that evening of a number of slides from the Society's cabinet, prepared by the late Dr. Carpenter in connection with his investigations into the shells of the mollusca. Mr. B. B. Woodward also exhibited some preparations.—Prof. Chas. Stewart referred to the views held upon shell structure at the present day, and, taking the common pinna shell as an example, demonstrated how its structure was built up. Besides studying the sections usually made, he recommended that shells should be broken and the fractured surfaces examined, if a correct idea of the formation of the shells was to be obtained.

Zoological Society, December 4.—Dr. Henry Woodward, F.R.S., Vice-President, in the chair.—The Secretary read an extract from a letter which had been addressed to the Colonial Office by the West India Committee, concerning the proposed introduction of the English starling or the Indian mynah into St. Kitts, West Indies, to check the increase of grasshoppers, which were causing great damage to the growing crops in that island.—Mr. R. Lydekker exhibited, on behalf of Mr. Rowland Ward, and made remarks upon the mounted skin of a female musk-ox which had been obtained from East Greenland.—Dr. C. I. Forsyth Major exhibited and made remarks on some remains of *Cyon* from Sardinia, and of a monkey (*Macacus*, sp. inc.) from Mauritius.—Mr. A. H. Cocks made some remarks on the period of gestation of the pine-marten (*Mustela martes*), which he had ascertained could not be less than ninety-four days and might possibly be as much as 106 days.—Mr. J. S. Budgett read a paper on the breeding-habits of *Protopterus*, *Gymnarchus*, and some other West African fishes, in which an account was given of a collecting trip made during last summer to the swamps of the Gambia River in search of the eggs of *Polypterus*. The eggs of *Polypterus* were not discovered, though a very young specimen, measuring only one inch and a quarter in length, was found. In this small specimen the dermal bones were not developed, and the external gills were of very great size, the base of the shaft being situated immediately behind the spiracle. The dorsal finlets formed a continuous dorsal fin. While Mr. Budgett was in search of the eggs of *Polypterus*, the underground nests of *Protopterus annectens* were found in abundance, and complete series of eggs and larvæ were preserved. The male *Protopterus* was found to live in the nest until the larvæ were fit to leave it. Nests were also found of the curious fish *Gymnarchus niloticus*. These were made in

about three feet of water, and floated on the surface. The nest was two feet long and a foot wide; the walls of the nest stood several inches out of the water around two sides and one end. The opposite wall was low, and here was the entrance to the nest. Nests of *Heterotis niloticus*, *Hyperopisus bebe* and *Sarcodaces odoë* were also described.—A series of papers on the collections made during the "Skeat Expedition" to the Malay Peninsula in 1899–1900 was read. Mr. J. Lewis Bonhote reported on the mammals, and enumerated the fifty-four species of which specimens had been obtained. One new species was described as *Mus ciliata*. Mr. N. Annandale gave a short description, illustrated with lantern slides, of the country traversed, and read the notes he had made on the habits and natural surroundings of the insects he had observed. Mr. F. F. Laidlaw gave an account of the frogs collected by himself and Mr. Annandale; they embraced examples of twenty-nine species, of which four, viz. *Rana signata*, *R. Lateralis*, *Bufo jerboa* and *Microhyla inornata*, had not previously been recorded from the Malay Peninsula. The earthworms collected during the expedition were reported upon by Mr. F. E. Beddard, who described from amongst them ten new species belonging to the genus Amyntas.—A communication was read from Dr. Arthur G. Butler containing an account of the butterflies collected by Mr. Richard Crawshay in the Kikuyu Country of British East Africa in the years 1899 and 1900. The species represented in the collection were 116 in number, six of which were described as new in the paper.—Mr. R. Newstead contributed a paper on a new scale-insect (*Walkeriana pertinax*), collected by H.B.M. Commissioner Alfred Sharpe, C.B., at Zomba, British Central Africa, which was stated to be probably the largest species of Coccid yet discovered, the maximum measurements being 20·50 mm. long and 10 mm. high. As in the genus *Callipappus* the abdomen was intus-suscepted, forming a pouch for the reception of the ova and the hatching of the larvæ. 6258 of the latter were taken from the body of a single female.

EDINBURGH.

Royal Society, November 19.—Prof. Copeland, Vice-President, in the chair.—The chairman gave the substance of communications from the Scottish Office, Whitehall, and from the Nobel Committee of the Royal Swedish Academy of Sciences, as to the Nobel Foundation.—In a paper on the diurnal range of temperature in the Mediterranean during the summer months, Dr. Buchan gave some important conclusions based on the observations made by the staff of the Austrian ship *Pola*. These had been taken at various depths, and a study of them showed that in water deeper than 100 fathoms a daily change of temperature could be detected to a depth of about 150 feet. Thus averaging from 50 distinct sets of observations, he found that the temperature of the surface waters in the afternoon was greater than the temperature in the morning by 1·5° F., and that this difference gradually diminished with increase of depth, having for example the value 0·3° F. at a depth of 100 feet. That such a depth should be reached by the solar radiation seemed very remarkable, and the process by which the heat was lost during the night seemed to demand a careful consideration of our theories of radiation.—Dr. Alexander Bruce read an elaborate paper on the topography of the gray matter and motor cell in the spinal cord, the results being demonstrated by a series of finely prepared lantern slides.

PARIS.

Academy of Sciences, December 3.—M. Maurice Lévy in the chair.—Study of the carbide of samarium, by M. Henri Moissan. A mixture of samarium oxide and carbon, submitted to the temperature of the electric furnace, gives easily a crystallised carbide of the formula SaC_2 comparable with the oxides of lanthanum, cerium, neodymium and praseodymium. This carbide decomposes cold water in a similar manner to the carbides of the alkaline earths, giving a complex mixture of hydrocarbons, rich in acetylene. In this respect samarium behaves more like the ytrrium group and differs from the cerium group of rare earths.—Observations of the comet, 1900 *b* (Borrelly-Brooks) made with the large equatorial of the observatory of Bordeaux, by MM. G. Rayet and A. Feraud. The positions of this comet were measured on nine evenings between September 13 and October 25. On the latter date the comet had still a very faint tail, and the nucleus was slightly elongated.—The changes of solar temperature and the variations of rain in regions surrounding the Indian Ocean, by Sir Norman Lockyer and Dr. W. J. S. Lockyer. A connection is traced between the occurrence of dry and wet seasons and the maximum and minimum temperatures of the sun, as determined by the area of sun spots.—New comparative researches on the products of combustion of different apparatus for lighting, by M. N. Gréhant. The products of combustion from incandescent burners, candles and petroleum lamps were compared, with especial reference to the amount of carbon monoxide produced. The results are best compared by examining the ratio of the volumes of $CO : CO_2$ produced. This ratio was 1 : 655 for the Auer burners, 1 : 1025 for the oil lamps and 1 to 1610 for the candles.—On isothermal surfaces, by M. A. Thybout.—On the minimum of certain integrals, by M. H. Lebesgue.—Geometrography in space, by M. Emile Lemoine.—On the theory of electrocapillary phenomena, by M. Gouy. The author states that the view generally held as to the causes of electrocapillary phenomena, the Helmholtz hypothesis of double layers, is not in accord with experiment. The view is here put forward that forces exist between the mercury and the ions or molecules of the dissolved body which are non-electrical. This leads to the conclusion that there exists in general a triple electric layer, which may, in certain cases, be reduced to a double layer.—Acidimetry of the aldehydes and ketones, by MM. A. Astruc and H. Murco. The behaviour of a large number of fatty and aromatic aldehydes and ketones towards helianthine A, phenolphthalein, and Porrier's blue has been studied. The results are in general accord with the thermochemical data.—On some reactions of substituted anilines, by M. Œchsner de Coninck. An account of the reactions between methyl-, dimethyl-, ethyl-, and diethyl-aniline and copper sulphate, chloride, and acetate, and nickel and cobalt chlorides.—On the presence of an iron thiocarbonate in the water of the Rhone, by M. H. Causse. At certain times of the year the Rhone water possesses the property of restoring the colour to Schiff's reagent. After proving that no aldehyde was present in the water, the reaction was proved to be caused by a thiocarbonate of iron, $FeCO_2S$, which was made synthetically in two or three ways. There appears to be some connection between the amount of this substance present in the Rhone water and the number of cases of typhoid fever in the Rhone valley.—Determination of overheating or under-heating of plaster of Paris in furnaces, by M. L. Périn.—Permeability of the external wall of the marine invertebrate, not only to water but also to salts, by M. R. Quinton. It is shown experimentally in a decisive manner that the external wall of the marine invertebrate is permeable, not only to water, but to such salts as sodium chloride and phosphate. Hence the higher marine invertebrate, although closed anatomically, is osmotically open, and hence resembles the lower marine invertebrate, physiologically and anatomically, in being a colony of marine cells.—A volatile poison, the cutaneous secretion of *Iulus terrestris*, by M. C. Phisalix. During a research on the action of this venom upon guinea-pigs, it was found that the poison was volatile; hence it is probable that the active principle is not an albumenoid material.—The large migratory Acridians of the Old and New World of the genus Schistocera; their changes in colour according to age and season; the physiological *rôle* of pigments; by M. J. Künckel d'Herculais.—On the disease of the carnation produced by *Fusarium Dianthi*, by M. G. Delacroix. The conidia of *Fusarium Dianthi* can be killed in seven hours by the vapour of carbon bisulphide. Ordinary formalin of commerce, diluted with one thousand parts of water, kills the chlamydospores in an hour.—On the simultaneous production of two nitrogen compounds in the crater of Vesuvius, by M. R. V. Matteucci. During the recent eruption, the simultaneous ejection of rocks covered with sal ammoniac and iron nitride was noticed, and these are regarded as being intimately related in their formation.—Remarks by M. Armand Gautier on the preceding paper.—On the tectonic continuity of Tonkin with China, by M. A. Leclère.—Chemical and mineralogical examination of the Lançon meteorite, by M. Stanislas Meunier.—On some therapeutic applications of light, by M. P. Garnault. Light may be utilised with great advantage in a certain number of diseases, and the results obtained are certainly due to its specific action. The cases most successfully treated are muscular and chronic articular rheumatism, various ulcers and chronic catarrh of the nose and ear.

NEW SOUTH WALES.

Royal Society, October 3.—The President, Prof. Liversidge, F.R.S., in the chair.—Marriage and descent among the Australian aborigines, by R. H. Mathews.—On the constituent of peppermint odour occurring in many Eucalyptus oils, part i., by Henry G. Smith. The first Eucalyptus oil was distilled by Dr. White in 1788, at Sydney, and owing to the great resemblance between this oil and that obtained from the peppermint *Mentha piperita*, he named the tree from which he had obtained the oil the "Peppermint Tree." Its botanical name is *Eucalyptus piperita*. Since then many other species of Eucalyptus have been found to have this peppermint odour, and are generally known as "peppermints." The constituent giving this odour has now been isolated. It occurs in greatest amount in the oil obtained from the leaves of *E. dives*, next in that of *E. radiata*, and in fair amount in the oils of several other species.—On the crystalline structure of gold nuggets from Klondyke, Victoria and New Zealand, by Prof. Liversidge, F.R.S. Sections of three nuggets from Klondyke were shown. The crystal faces are comparatively small, and the nuggets have a granular structure, as if built up of separate grains, of one or two millimetres in diameter. They are also more fissured and contain more cavities than usual. The sections of Victorian (Australian) and New Zealand nuggets are also made up of small crystals, and they present numerous small cavities after the removal of the quartz and iron oxide by treatment with hydrofluoric and hydrochloric acids, so that the sections present quite a different appearance to the very compact and largely crystallised nuggets from West Australia.

DIARY OF SOCIETIES.

THURSDAY, DECEMBER 13.

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MATHEMATICAL SOCIETY, at 5.30.—The Syzygetic Theory of Orthogonal Bivariants: Prof. Elliott, F.R.S.—On Discriminants and Envelopes of Surfaces: R. W. Hudson.—Note on the Inflexions of Curves with Double Points: H. W. Richmond.—On some Properties of Groups of Odd Order, ii.: Prof. Burnside, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Possible continuation of Discussion on Mr. Langdon's paper.—*Time permitting*: Rapid Variations in the Current through the Direct Current Arc: W. Duddell.

CHEMICAL SOCIETY, at 8.30.—Rammelsberg Memorial Lecture: Prof. H. A. Miers, F.R.S.

FRIDAY, DECEMBER 14.

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MALACOLOGICAL SOCIETY, at 8.—Note on *Bensonia* and an apparently undescribed Species, *B. mimela*: W. T. Blanford.—Note on *Bensonia mainwaringi* and *Macrochlamys dalingensis*: W. T. Blanford.—Further Notes on the British Pliocene Non-Marine Mollusca: A. S. Kennard and B. B. Woodward.—The Anatomy of *Beddomea* and the Relationships of *Amphidromus*: Henry A. Pilsbry.

INSTITUTION OF MECHANICAL ENGINEERS, at 8.—Power-Gas and Large Gas-Engines for Central Stations: H. A. Humphrey.

SATURDAY, DECEMBER 15.

ESSEX FIELD CLUB (Essex Museum of Natural History, Stratford), at 6.30.—Notes on the Mollusc *Paludestrina jenkensi*, Smith, in Essex and elsewhere: A. S. Kennard and B. B. Woodward.—Aquatic Autocrats and Fairies (Lecture): Fred. Enock.

MONDAY, DECEMBER 17.

SOCIETY OF ARTS, at 8.—Electric Oscillations and Electric Waves: Prof. J. A. Fleming, F.R.S.

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INSTITUTION OF CIVIL ENGINEERS, at 8.—*Papers to be further discussed*: The Signalling on the Waterloo and City Railway; and Note on the Signalling of Outlying Siding Connections: A. W. Szlumper.—Signalling on the Liverpool Overhead Railway: S. B. Cottrell.—*Papers to be read, time permitting*: Glasgow Bridge: B. Hall Blyth.—Railway Bridge over the Fitzroy River, at Rockhampton, Queensland: W. J. Doak.—The Niagara Falls and Clifton Steel Arch Bridge: L. L. Buck.

ROYAL STATISTICAL SOCIETY, at 5.—The Statistical Results of the State Monopoly of Spirits, established in Russia in 1895, and its Influence on the Economic Development and Morality of the Population: Alexis Raffalovich.

ROYAL PHOTOGRAPHIC SOCIETY, at 8.—Photography in War: H. C. Shelley.

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THURSDAY, DECEMBER 20.

LINNEAN SOCIETY, at 8.—On the Structure and Habits of the *Ammocharidæ*: Arnold T. Watson.—The Flora of Vavau, one of the Tonga Islandx: J. H. Burkill.—Warning Colours in Insects: Prof. E. B. Poulton, F.R.S.

INSTITUTION OF ELECTRICAL ENGINEERS, at 8.—Lecture on the Electrical Engineers (R.E.) in South Africa: Lieut.-Colonel Crompton.

CHEMICAL SOCIETY, at 8.—On the Union of Hydrogen and Chlorine: J. W. Mellor.

FRIDAY, DECEMBER 21.

INSTITUTION OF CIVIL ENGINEERS, at 8.—The Use of Geometrical Methods in investigating Mechanical Problems: C. E. Inglis.

CONTENTS.

THURSDAY, DECEMBER 20, 1900.

A MODERN SCIENTIFIC INDUSTRY.

Jena Glass and its Applications to Science and Art. By Dr. H. Hovestadt. Pp. xii + 429. (Jena: Fischer, 1900.)

THIS is a volume of some four hundred pages, in which Dr. Hovestadt has collected a mass of information about the Jena glass.

In a report on the scientific apparatus of the London Exhibition of 1876, Abbe called attention to the need for progress in the art of glass making if the microscope were to advance, and to the necessity for obtaining glasses having a different relation between dispersion and mean refractive index than that found in the material then at the disposal of opticians.

He referred to the attempts made in England by Harcourt and Stokes with this object, and to the causes of their failure.

The task thus indicated was undertaken in 1881 by Abbe himself and Schott at Jena. The first catalogue of the Jena Laboratory, published in 1886, contains these words: "The industrial undertaking which is here announced for the first time arose out of a scientific investigation into the connection between the optical properties of amorphous fluxes and their chemical constitution."

The experimental work was only rendered possible by repeated and large subventions from the State. The immediate consequence of the undertaking was that by 1888 nearly all the glass required for optical work in Germany was of home manufacture; in a few years more an export trade in the raw glass began, the value of which in 1898 was over 30,000*l.*, while the value of the optical instruments, such as telescopes, spectacles, field glasses and the like, exported in the same year was nearly 250,000*l.* The trade at present employs some 5000 workmen.

When Abbe and Schott began their work, some six elements only entered into the composition of glasses. By 1888 it had been found possible to combine with these six quantities, up to at least 10 per cent., of twenty-eight additional elements, and the effect of each of these on the refractive index and dispersion had been determined.

Thus, for example, these investigators had found that by the addition of boron the ratio of the length of the blue end of the spectrum to that of the red is reduced; while fluorine, potassium and sodium produce opposite results.

Now an ordinary achromatic lens, uniting two colours of the spectrum, is formed by combining a crown glass lens with one of flint glass having equal total dispersion; but though the total dispersion is the same for the two it is differently distributed throughout the spectrum. In the flint glass the dispersion of the blue end is greater, that of the red less, than in the crown; hence the light from a white source is not white after traversing the lens; a "secondary" spectrum remains, and it was the existence of this which rendered the progress of the microscope so difficult. Abbe's experiments showed how the difficulty was to be met. By combining a high proportion of boron with flint glass, its spectrum became more nearly the same as that of a crown glass. Such a glass had been made by Harcourt many years previously, while a glass containing phosphates instead of silicates is found to have the same dispersion as, combined with a higher refractive index than, the ordinary crown glasses, and therefore serves better to achromatise the borate-flint glass. In fact, Abbe showed that with two such glasses it is possible to combine three colours instead of only two; the outstanding spectrum is greatly reduced in length, and is called a "tertiary" instead of a "secondary" spectrum.

Again, the ordinary microscope lens of two glasses can be corrected for axial spherical aberration for one colour only. Abbe showed that the new borate-phosphate lenses could, by combination with a lens of fluor-spar, have their axial spherical aberration corrected for two colours. These lenses he called apochromatic.

It was found more difficult to reduce the secondary spectrum by lengthening the red end of the spectrum of the crown glass. This required the addition, as we have said, of fluorine, potassium or sodium. The effect of sodium is small; glasses with a large amount of potassium can be made, but are very hygroscopic, while the introduction of fluorine though it was successfully effected, is involved with many difficulties.

The book under review gives, in its first two chapters, an account of the preliminary work of Abbe and Schott, and full details as to the optical properties of the glasses now made. The next four chapters deal with the optical instruments manufactured out of the glasses.

We have already referred to the fundamental improvement in the microscope rendered possible by their use; the problem to be solved in the case of a photograph lens was somewhat different. It follows, from the work of von Seidel, that, with the ordinary crown and flint glasses, the conditions for achromatism and for flatness of field cannot be satisfied together. To do this it is necessary to find a glass of high refractive index and low dispersive power, or *vice versâ*. In ordinary glasses refractive index and dispersive power go together.

Thus, ordinary hard crown glass has a refractive index of 1·518 and a dispersive power of ·0166, while for extra dense flint the figures are 1·717 and ·0339. An achromatic lens might be constructed out of these two glasses, but the field could not be flat.

By introducing barium, however, into the crown glass, a change is produced in this respect. Thus for barium silicate crown the refractive index and dispersive power are 1·573 and ·0173, while for soft crown they are 1·515 and ·0177. With these two glasses, the problem of constructing a photographic object-glass possessing achromatism and flatness of field becomes possible. For the various methods of solution we must refer to the book[1] itself, in which also will be found details as to the use of the glasses for telescopic lenses.

The mechanical properties of glass are next considered, and in Chapter ix. we come to a careful discussion of the imperfect elasticity of glass, specially in connection with thermometry.

[1] See also "Contributions to Photographic Optics," by Dr. Otto Lummer, translated by Prof. S. P. Thompson.

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